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Clifty Creek

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EA Project CCI61

should be PR3019

FINAL REPORT
CLIFTY CREEK STATION
IMPINGEMENT STUDY
AND IMPACT ASSESSMENT

Prepared for

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1. INTRODUCTION

The National Pollution Discharge Elimination System Permit for the Clifty Creek Station, owned and operated by Indiana-Kentucky Electric Corporation, a wholly owned subsidiary of Ohio Valley Electric Corporation, contains a requirement that the owners conduct a fish impingement study. This NPDES Permit was issued by the State of Indiana and became effective March 6, 1985. Section 316 (b) of the Clean Water Act requires "...that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." EA Science and Technology (EA) was selected by IKEC to conduct the required study and evaluate the impact cooling water intake structure on the Ohio River biota.

The Clifty Creek Station is situated on the Indiana shore of the Ohio River near Madison, Indiana at River Mile (RM) 560 (Figure 1). It is a coal-fired, once-through cooled steam electric generating plant with six generating units, each with a rated capacity of 217 megawatts (MW). The steam produced in the boiler of each of Clifty Creek Station's six generating units is used to drive a turbine-generator in order to produce electric power. The spent steam exhausts into the turbine condenser where it is condensed by circulating cooling water and then returned to the boiler for further steam production. The condenser cooling water system at Clifty Creek Station is a "once-through" system. The cooling water, which is withdrawn from the Ohio River at approximately 960,000 gallons per minute when the plant is at normal full-load operation, is circulated through the condenser tubes one time for cooling purposes and then returned to the river. The intake structure for the Clifty Creek Station is a large reinforced concrete screen house that is situated at the end of a 300-foot long approach channel (Figures 1 and 2). The long axis of the screen house runs parallel to the river. The approach channel is bounded by the screen house to the north, discharge training wall to the west, an earthen embankment to the east and the Ohio River to the south. The river has silted in an area (referred to hereafter as the mud bar) of approximately 0.64 acres in the approach channel which is partially exposed at normal pool elevation. Across the mouth of the approach channel is a floating catwalk that is used to keep floating trash out of the approach channel.

The screen house is divided into six sections, one for each unit, with a dividing wall between each section (Figure 2). Each section contains three intake gates (ports), three trash racks, three traveling screens and two circulating water pumps each rated at 116.3 MGD.

Since all units are the same, the water movement through one unit only will be discussed. From the approach channel, water moves into the screen house section for a particular unit through the three intake gates. Upon entering the screen house, water flows through a trash rack, which prevents coarse refuse from reaching the traveling screens (Figure 3). Trash on the rack is removed by mechanical rakes controlled from the screen house operating floor.

Beyond the trash racks, the water is further screened by one of three vertical traveling screens. Each traveling screen is an endless belt of screen baskets or frames 8-feet wide and 2-1/2 feet high with 3/8-inch mesh screen. The

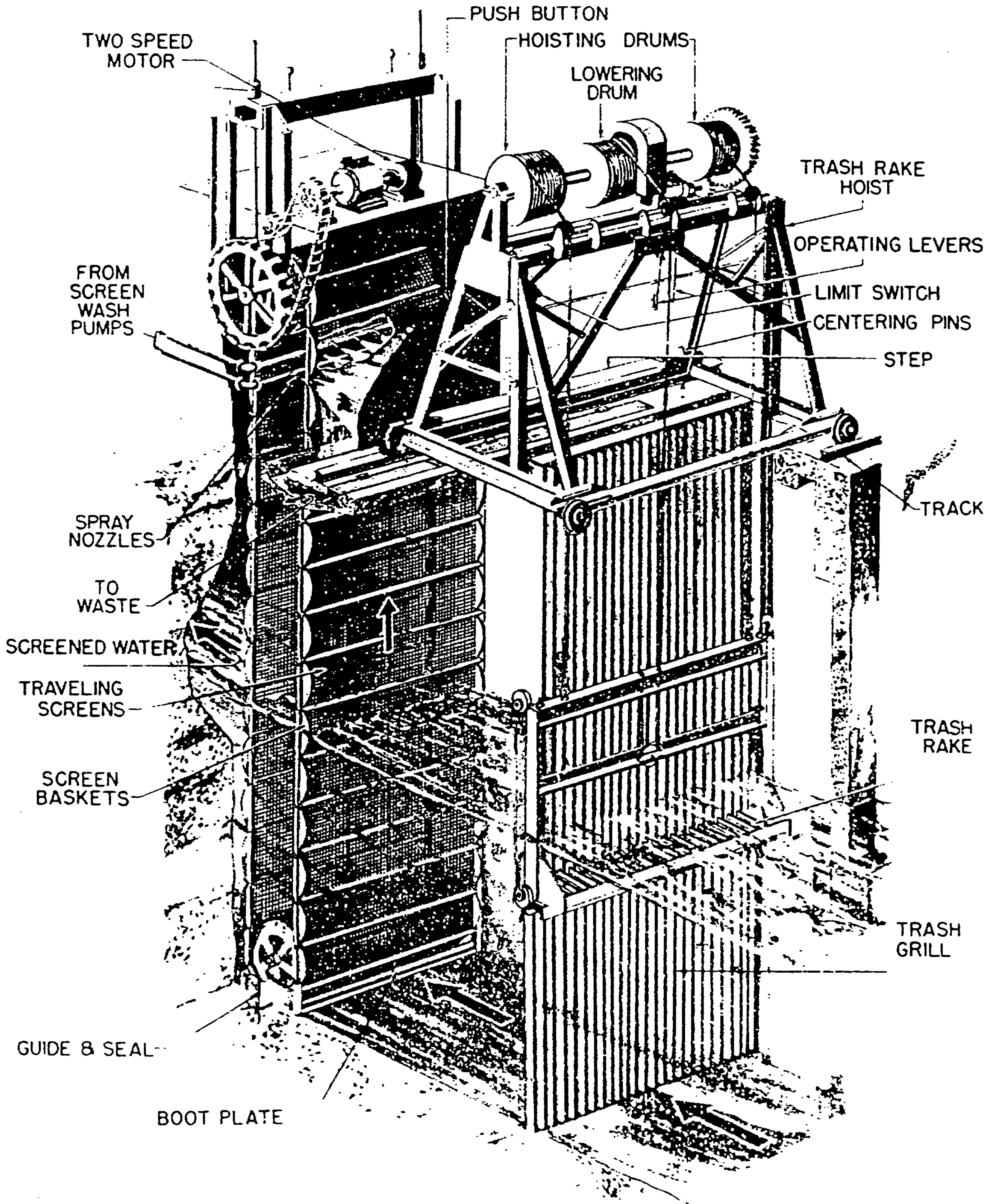

FIG. 3
TRAVELING SCREENS
AND TRASH RAKE

traveling screen is motorized and travels in a vertical direction. Debris that collects on the screens is removed by using streams of high pressure water while rotating the screens and sluiced to a common trash trough or sluiceway. This wash water issues from a series of spray nozzles near the top of the screen and is supplied by screen wash pumps. The sluiceway passes in front of all the traveling screens and collects the screen wash from each, then exits at the west side of the screenhouse, and discharges into the circulating water discharge canal. On dates when impingement samples needed to be collected, a collection basket (see Section 2 for details of the basket) was placed so that it intercepted the flow of water from the sluiceway after it left the screenhouse but before it was returned to the discharge canal.

2. METHODS

2.1 SCHEDULE AND FIELD PROCEDURES

Impingement samples were collected on a total of 49 dates over a 13-month period beginning in December 1985 and continuing through December 1986. From December 1985 through February 1986 samples were collected twice a month (6 dates), and from March through December 1986 samples were collected weekly (43 dates). Sampling was conducted on different days of the week each period. Each 24-hr sample was typically divided into three 8-hr intervals.

Sampling was initiated on each of the 49 dates by having plant personnel rotate and wash (backflush) all the traveling screens at an appointed time (usually midnight). This served to clear the screens of any fish or debris that had accumulated prior to the 24-hour sampling period. EA personnel arrived eight hours later to set the sample collection basket in position to collect the fish that had been impinged on the screens during that 8-hour interval. Subsequent collections took place at 16 hours and at 24 hours.

The collection basket, which was approximately 4-ft square by 7-ft high, was constructed of 3/8-inch mesh screen. It was suspended over the west side of the screen house using a winch and crane system. The basket was placed so that all the flow in the sluiceway passed through it. Once the basket was in place, plant personnel rotated and washed the screens, either singly or in combination.

When the debris and fish load was low (most of the spring and summer) several units were usually backflushed simultaneously for 20-30 minutes. When the debris and/or fish load was high, screens were backflushed individually or in pairs. This approach successfully prevented the basket from clogging, and thereby overflowing, on all but one date. On 12 December 1986, the debris load was so great that clogging occurred during the first 8-hr interval, even though only one unit was backflushed at a time. Overflowing was prevented during the second and third 8-hour intervals on this date by backflushing for only 10 minutes (instead of the usual 20 minutes), retrieving and emptying the basket, resetting the basket and then continuing the backflushing process for a second 10-minute interval to ensure that the screens were completely cleaned. Observations in the field on this date indicated that the number of fish caught was evenly distributed between the two 10-minute samples so the catch values obtained during the initial 8-hour sampling period were doubled to account for the fish that had been lost when the basket overflowed.

Each time the basket was retrieved, the fish and debris that had accumulated inside were dumped onto the cement platform outside the screenhouse. Fish were carefully sorted out from the debris and placed into three buckets; one for gizzard shad, one for freshwater drum, and one for all other species. Fish obviously dead prior to impingement were identified, when possible, and counted. These data are reported but were not used in estimating the annual impingement rate.

Gizzard shad, freshwater drum, skipjack herring, and large, easy to identify species (e.g., paddlefish, adult sauger and catfish) were sorted, processed, and discarded in the field. Unless a senior EA biologist was present, all other species were preserved in 10% formalin for subsequent identification in the lab.

2.2 SAMPLE PROCESSING (FIELD OR LAB)

Processing, both in the lab or the field, consisted of weighing (nearest gram for fish weighing less than 50 g, nearest 5 g for fish weighing 50-1000 g, and nearest 50 g for fish weighing more than 1000 g) and measuring (total length to the nearest millimeter) each fish, up to a maximum of 50 per species per 8-hour interval. Scales were checked at the beginning, middle, and end of the study and each time found to be in calibration. Data were recorded on standard EA fish data sheets. When 51-500 fish of a given species were collected, a subsample of 50 was processed and the remainder were batch weighed. When 500 to 1000 fish of a species were collected, 10% were processed and the remainder batch weighed. When more than 1000 fish of a species was collected, 100 were processed and the remainder was batch weighed. For samples containing more than 1000 fish, the number of fish being batch weighed was estimated based on the average weight of the 100-fish subsample. Subsampling was often necessary for gizzard shad and freshwater drum, rarely necessary for bluegill and white bass, and never necessary for other species. The gizzard shad and freshwater drum subsamples were separated into small, medium, and large size categories according to the proportion that each size category contributed to the total catch. Thus, if small gizzard shad composed 80% of the total shad catch, the 50-100 fish subsample was also composed of 80% small gizzard shad. However, because of the fact that large fish were usually represented by only a few individuals, these few large individuals were typically processed regardless of the percentage they contributed to the total.

In the laboratory all identifications were made by EA's project manager and all weighing and measuring was done by a technician. Species identifications were made using Pflieger (1975), Smith (1979), Trautman (1981), Becker (1983), and Page (1983). Nomenclature followed the most recent guidance of the American Fisheries Society (Robins et al. 1980). Information regarding the geographic distribution of fishes was based primarily on Lee et al. (1980) and Pearson and Krumholz (1984). A voucher collection containing a representative of each species collected was compiled. Selected species were sent to Dr. David Etnier, University of Tennessee, for confirmation.

2.3 PHYSICAL AND CHEMICAL DATA

Water temperature data at the plant's intake and the volume of circulating water on each sampling date was collected and compiled by plant personnel, and provided to EA. EA field personnel recorded river stage readings from a gage in the discharge canal. Intake current speed was measured on 41 of the 49 sampling dates using either a Marsh McBirney or General Oceanics current meter. Measurements were made near the top, middle, and bottom of each of the 18 intake gates. Directional measurements were made on nine dates during the late summer and early fall when the river was low enough to safely use the catwalk located at about elevation 425 ft.

Duplicate dissolved oxygen measurements were made during each 8-hour sampling interval near the middle of one of the intake ports for Unit 3. The measurements were made using a Winkler titration (APHA et al. 1981).

All velocity and dissolved oxygen data collected are presented in Appendix A.

2.4 DATA ANALYSIS

Length-frequency tables and figures were prepared for gizzard shad, freshwater drum, bluegill, and white bass, the four most abundant species, and also for sauger. Spearman's Rank Correlation test was used to determine whether total impingement or the catches of the four most abundant species were correlated with intake temperature, median intake velocity, or river stage (which served as a surrogate for river flow). Both ranked and unranked catch statistics were also compared against these same three variables using Pearson correlation coefficients.

Estimates of semi-monthly impingement rates during the first three months of the study (when samples were collected twice a month) were made by multiplying the 24-hour catches by 15. Weekly fish impingement estimates (for total fish catch and by species) were made by multiplying the 24-hour catches by 7. The annual impingement estimates were made by summing the weekly and semi-monthly estimates for twelve-month periods from December 1985 through November 1986 and January 1986 through December 1986. An estimate was made of fish impingement for the thirteen-month period December 1985 through December 1986.

3. RESULTS AND DISCUSSION

3.1 SPECIES ABUNDANCE AND COMPOSITION

Twenty-four hour collections on the 49 sampling dates from December 1985 through December 1986 yielded a total of 175,659 fish representing 53 species (Table 1). Gizzard shad were abundant (149,089 individuals) and accounted for nearly 85 percent of the catch numerically, while freshwater drum were common to abundant (22,357) and accounted for 13 percent of the total catch. These two species accounted for 98 percent of the fish collected by number (Table 1). Numerically, the only other species commonly collected were bluegill (1923 individuals, 1.1%) and white bass (975 individuals, 0.6%). All other species were represented by fewer than 200 individuals.

By weight, gizzard shad (77 percent) and drum (15 percent) again ranked first and second, respectively, followed by white bass and sauger (each 1.5 percent), and bluegill (1.3 percent). No other species accounted for more than 1 percent of the total fish weight.

In contrast to the common species, nine species -- silver lamprey, goldfish, central stoneroller, sand shiner, ghost shiner, northern hog sucker, rainbow smelt, spotted bass and stonecat -- were represented by single specimens. Although these species were rare in this study, all are known to occur in the Ohio River except rainbow smelt (Pearson and Krumholz 1984). This represents the first report of rainbow smelt in the entire Ohio River drainage (Pearson, personal communication). The specimen has been deposited at the Ohio State Museum of Zoology (Catalogue No. 68612).

No state listed threatened or endangered species were collected during the present study (IDNR 1984).

The most appropriate data set with which to make comparisons regarding species composition or abundance was collected during an earlier (1977-78) one-year impingement study at the Clifty Creek Station (Energy Impact Associates 1978). During the previous study, 32-hour collections were made during 41 two-day periods. This level of effort is equivalent to fifty-five 24-hour collections, thereby making the sampling efforts quite comparable between the earlier and present studies (55 days in the earlier study vs. 49 days in the present study). During 1977-78, a total of 391,070 fish were collected, about twice the number collected during the present study. However, 231,339 fish were collected during one 32-hour period during the previous study. If the results from that one period were excluded, the total in the 1977-78 study would be 159,731 fish; a figure comparable to the total in the present study of 175,659. If a similar adjustment is made for the weight data, the results are again comparable; 1640 kg in 1977-78 vs. 1460 kg in the present study.

In terms of species composition, the results of the two studies are in good agreement. Of the 57 species reported during the 1977-78 study (Energy Impact Associates 1978), 42 were collected during the present study. The following 15 species (number of individuals reported is in parentheses) were reported during the previous study but not during the present study:

TABLE 1 NUMBER AND RELATIVE ABUNDANCE OF FISHES IMPINGED AT THE CLIFTY CREEK STATION, DECEMBER 1985 THROUGH DECEMBER 1986

Common Name	Scientific Name	Number		Weight	
		Number	%	Grams	%
Silver lamprey	Ichthyomyzon unicuspis	1	<0.01	80	0.01
Paddlefish	Polyodon spathula	18	0.01	2,530	0.17
Longnose gar	Lepisosteus osseus	12	0.01	3,085	0.21
Skipjack herring	Alosa chrysochloris	117	0.07	4,185	0.29
Gizzard shad	Dorosoma cepedianum	149,089	84.87	1,116,774	76.51
Threadfin shad	D. petenense	25	0.01	131	0.01
Goldeye	Hiodon alosoides	3	<0.01	960	0.07
Mooneye	H. tergisus	68	0.04	6,073	0.42
Rainbow smelt	Osmerus mordax	1	<0.01	2	<0.01
Goldfish	Carassius auratus	1	<0.01	3	<0.01
Carp	Cyprinus carpio	32	0.02	533	0.04
Golden shiner	Notemigonus crysoleucas	11	0.01	135	0.01
Fathead minnow	Pimephales promelas	3	<0.01	14	<0.01
Creek chub	Semotilus atromaculatus	2	<0.01	61	<0.01
Spotfin shiner	Notropis spilopterus	4	<0.01	4	<0.01
Emerald shiner	N. atherinoides	197	0.11	917	0.06
Central stoneroller	Campostoma anomalum	1	<0.01	11	<0.01
Mimic shiner	Notropis volucellus	8	<0.01	10	<0.01
Sand shiner	N. stramineus	1	<0.01	3	<0.01
River shiner	N. blennius	5	<0.01	16	<0.01
Silver chub	Hybopsis storeriana	57	0.03	1,165	0.08
Unid. shiner	Notropis spp.	4	<0.01	4	<0.01
River carpsucker	Carpiodes carpio	3	<0.01	2,590	0.18
Quillback	C. cyprinus	50	0.03	5,291	0.36
White sucker	Catostomus commersoni	11	0.01	144	0.01
Unid. sucker	Catostomidae	2	<0.01	4	<0.01
Northern hog sucker	Hypentilium nigricans	1	<0.01	17	<0.01
Smallmouth buffalo	Ictiobus bubalus	14	0.01	7,101	0.49
Spotted sucker	Minytrema melanops	5	<0.01	46	<0.01
Silver redhorse	Moxostoma anisurum	2	<0.01	557	0.04
Golden redhorse	M. erythrurum	2	<0.01	715	0.05
Shorthead redhorse	M. macrolepidotum	5	<0.01	1,742	0.12
Carpsucker or buffalo	Ictiobinae	1	<0.01	1	<0.01
Unid. redhorse	Moxostoma spp.	1	<0.01	8	<0.01
Blue catfish	Ictalurus furcatus	6	<0.01	69	<0.01
Black bullhead	I. melas	6	<0.01	275	0.02
Channel catfish	I. punctatus	144	0.08	5,286	0.36
Stonecat	Noturus flavus	1	<0.01	4	<0.01
Flathead catfish	Pylodictus olivaris	22	0.01	1,051	0.07
White bass	Morone chrysops	975	0.56	21,214	1.45
Striped bass	M. saxatilis	30	0.02	2,052	0.14
Hybrid bass	M. spp.	7	<0.01	1,247	0.09
Rock bass	Ambloplites rupestris	4	<0.01	21	<0.01
Green sunfish	Lepomis cyanellus	56	<0.01	48	<0.01
Warmouth	L. gulosus	49	0.03	1,165	0.08
Bluegill	L. macrochirus	1,923	1.09	19,081	1.31
Longear sunfish	L. megalotis	35	0.02	1,494	0.10
Spotted bass	Micropterus punctulatus	1	<0.01	255	0.02

TABLE 1 (cont.)

Common Name	Scientific Name	Number Number	Number %	Weight Grams	Weight %
Largemouth bass	*M. salmoides*	30	0.02	1,228	0.08
White crappie	*Pomoxis annularis*	49	0.03	1,458	0.10
Black crappie	*P. nigromaculatus*	38	0.02	1,919	0.13
Unid. sunfish	*Lepomis* spp.	15	0.01	165	0.01
Hybrid sunfish	*Lepomis* spp.	12	0.01	193	0.01
Sauger	*Stizostedion canadense*	139	0.08	22,089	1.51
River darter	*Percina shumardi*	8	<0.01	43	<0.01
Yellow perch	*Perca flavescens*	3	<0.01	108	0.01
Walleye	*Stizostedion vitreum*	35	0.02	438	0.03
Logperch	*Percina caprodes*	8	<0.01	136	0.01
Freshwater drum	*Aplodinotus grunniens*	22,357	12.73	223,668	15.32
Total Fish		175,659	100.00	1,459,619	100.00

American eel (1)	Redear sunfish (1)	Bluntnose minnow (1)
Bigmouth buffalo (8)	Banded sculpin (2)	Yellow bullhead (1)
River redhorse (2)	Bigeye shiner (1)	Brown bullhead (34)
Pumpkinseed (3)	Common shiner (2)	Fantail darter (1)
Smallmouth bass (7)	Rosyface shiner (508)	Coho salmon (2)

Except for brown bullhead and rosyface shiner, all of these species were either rare or uncommon in the earlier study, so their absence during the current study is not surprising. The brown bullhead was quite common in the 1977-78 impingement catch but was not collected during the present study.

The 508 rosyface shiners reported in the earlier study may have been mis-identified emerald shiners as these two species are easily confused (Trautman 1981). The earlier study reported rosyface shiner to be far more abundant than emerald shiner (508 vs. 36) even though the emerald shiner is considered to be the most abundant fish in the river while rosyface shiner is rare (Pearson and Krumholz 1984). The two common shiners reported previously were probably striped shiners as the Clifty Creek area lies well outside the accepted range of the common shiner (Lee et al. 1980). These species are very similar in appearance and were originally considered subspecies until 1961 (Trautman 1981, Becker 1983).

Eleven species were found during the current study that were not reported during the earlier study:

N. hog sucker	Blue catfish
Threadfin shad	Stonecat
Central stoneroller	Striped bass
Fathead minnow	Walleye
Mimic shiner	Rainbow smelt
Ghost shiner	

All of these species are known from the Ohio River except for rainbow smelt (Pearson and Krumholz 1984). The origin of the single rainbow smelt that was captured is unknown. The appearance of striped bass in this section of the river is obviously attributable to the extensive stocking of this species that has occurred in the river during the last decade. For example, the Commonwealth of Kentucky presently stocks the McAlpine Pool with striped bass at a rate of 10 per acre (B. Keinman, personal communication). In addition to the white and striped bass that were reported, we found a number of what appear to be white x striped bass hybrids. These are probably from stockings the Commonwealth of Kentucky makes in the Kentucky River or from stockings in the mainstem done each year by the State of Ohio (B. Keinman, personal communication).

With regard to separating out members of the genus Morone it is worth noting that the characteristic most commonly used to separate white from striped bass (standard length divided by body depth) did not work on most of the juvenile specimens we examined. Most of the subadult white bass we examined were more slender than is normally the case and would have keyed out incorrectly as striped bass if only this characteristic had been used.

The mimic shiners we examined all appeared to be the vickliffi subspecies of Notropis vollucellus, which many taxonomists believe is specifically distinct from the mimic shiner, rather than just a subspecies. Our report of ghost shiner is based on a single specimen in rather poor condition that is either Notropis v. vickliffi or N. buchanani, and therefore it is not listed separately in Table 1.

The 35 small valleye we collected was somewhat surprising since it was not reported during the previous study. Pearson and Krumholz (1984) suggest that valleye populations are declining in the river and that recent studies at RM 570-580 yielded 30-50 saugers for every valleye caught. The catch ratio in this study was about 4 sauger to every valleye caught.

Gizzard shad were, by far, the most abundant species during each of the studies and its absolute and relative abundance appears to have changed little between the two study periods (86 percent of the catch [by number] in 1977-78 vs. 85 percent in the present study). However, some obvious changes in the relative abundance of other commonly impinged species have occurred (Table 2). The most dramatic change was the large reduction in skipjack herring impingement. In 1977-78 nearly 34,000 skipjack herring were impinged compared to only 117 during the present study (Table 2). In the 1977-78 study, skipjack herring was the second most abundant species, both by number and weight. In the present study, skipjack ranked eighth by number and tenth by weight (Table 2).

The impingement catch declined for the majority of the species for which there were sufficient historical data. Among 20 species represented in one or both of the impingement studies at the Clifty Creek Station by more than 30 individuals, the catch has declined for 16 species, stayed the same for 2 species, and increased for 2 species (Table 3). Among the 16 species exhibiting declines, the greatest decreases in impingement catch totals were exhibited by skipjack herring (288-fold decrease), smallmouth buffalo (30), golden redhorse (22), mooneye (17), quillback (15), and sauger (12), all of which showed declines of more than 10-fold. The catch totals for warmouth and channel catfish were essentially comparable during the two study periods. Bluegill and freshwater drum were impinged at twice the rate reported in the earlier study.

It is also worth noting that impingement losses for most sport fishes have either declined (e.g., white crappie, black crappie, white bass, brown bullhead, and especially sauger) or stayed the same (e.g., channel catfish and warmouth). Bluegill is the only sport species whose impingement total has increased, but that increase was fairly small (<2-fold) and consisted mostly of young-of-the-year fish (see Section 3.3).

3.2 SEASONAL AND TEMPORAL PATTERNS

As expected, the impingement catch at the Clifty Creek Station varied considerably among dates (Figure 4). However, despite this variability, two distinct periods for catch rates were evident. From 1 April through 3 September, less than 200 fish were impinged on 22 of the 23 sampling dates. The catch was less than 100 fish per date on 13 of these 22 dates, with the

TABLE 2 COMPARISON BETWEEN THE IMPINGEMENT CATCHES OF THE 10 MOST ABUNDANT SPECIES (BY NUMBER OR WEIGHT) AT THE CLIFTY CREEK STATION DURING 1985-86 WITH THOSE DURING 1977-78

1985-86			1977-78		
	No.	Wt (kg)		No.	Wt (kg)
Gizzard shad	149,089	1,117	Gizzard shad	337,372	2,926
Freshwater drum	22,357	224	Skipjack herring	33,740	188
Bluegill	1,923	19	Freshwater drum	10,773	149
White bass	975	21	White bass	2,211	64
Emerald shiner	197	1	Sauger	1,629	78
Channel catfish	144	5	Mooneye	1,130	9
Sauger	139	22	Bluegill	1,003	7
Skipjack herring	117	4	Quillback	732	7
Mooneye	68	6	White crappie	429	3
Silver chub	57	1	Smallmouth buffalo	416	5
Quillback	50	5	Channel catfish	199	10
Smallmouth buffalo	14	7	Silver chub	187	2
			Longnose gar	93	31

TABLE 3 COMPARISON OF HOW THE NUMERICAL IMPINGEMENT CATCH TOTALS AT THE CLIFTY CREEK STATION CHANGED BETWEEN 1977-78 AND 1985-86

Change Relative to the 1977-78 Numerical Catch*

Increased	No Change	Decreased
Freshwater drum (2.1)**	Channel catfish	Skipjack herring (288)
Bluegill (1.9)	Warmouth	Smallmouth buffalo (30)
		Golden redhorse (22)
		Mooneye (17)
		Quillback (15)
		Sauger (12)
		White crappie (8.8)
		Longnose gar (7.8)
		Paddlefish (5.2)
		Silver chub (3.3)
		Black crappie (2.5)
		White bass (2.3)
		Carp (1.9)
		Emerald shiner (see text)
		Brown bullhead (see text)
		Gizzard shad (see text)

* Only species represented by >30 individuals in one of the time periods are considered.

** Number in parentheses shows how many fold the 1985-86 catch has increased or decreased relative to the 1977-78 catch.

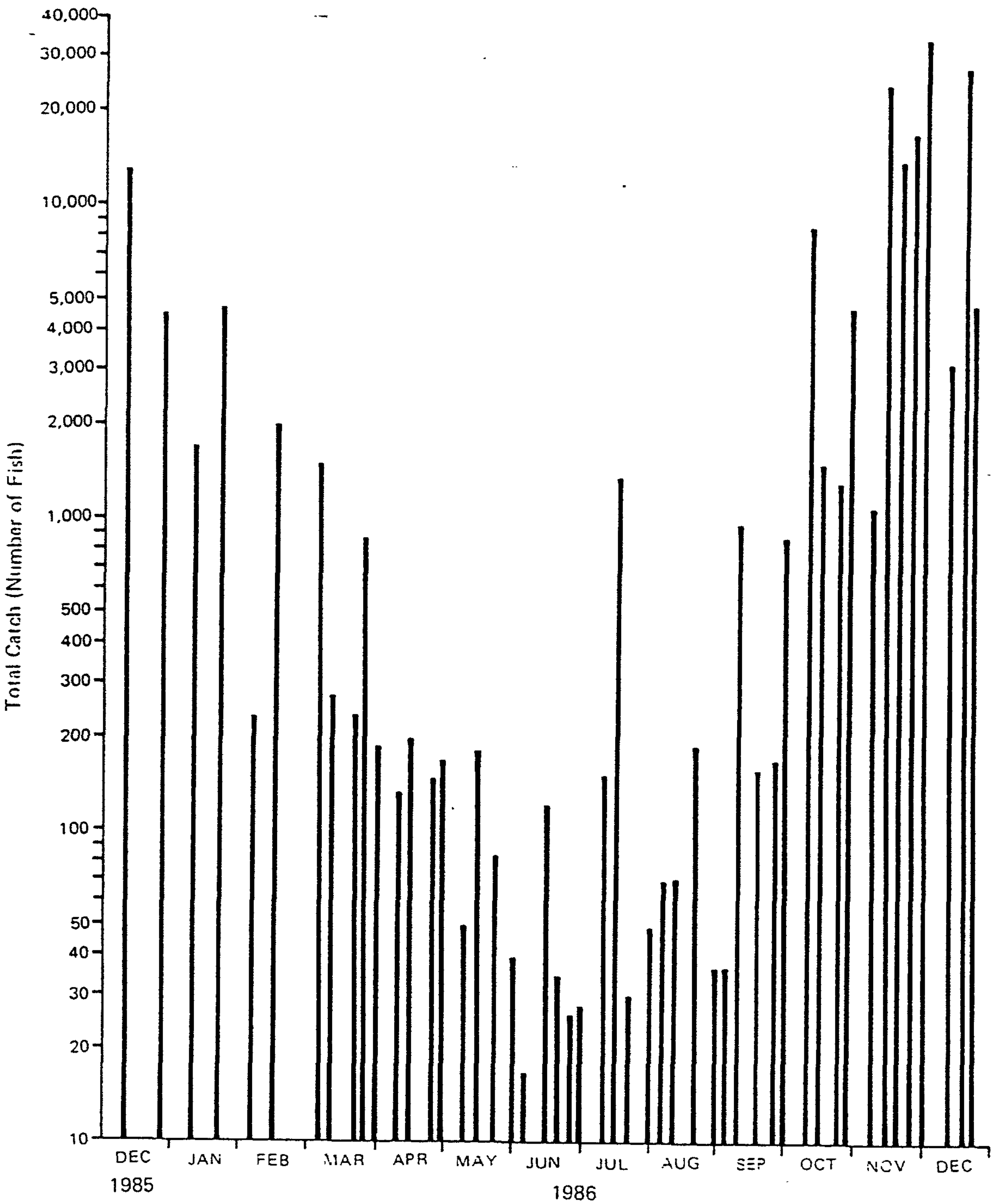

Figure 4. Total impingement catch per sample at the Clifty Creek Station for the period December 1985 through December 1986.

catch typically being lowest in the summer (Figure 4). Conversely, the catch was much higher during the fall and winter with more than 1000 impinged fish being collected on 18 of 26 fall/winter dates, and more than 10,000 fish being impinged on 6 dates. Because gizzard shad dominated the total catch, the pattern described above also describes the pattern followed by gizzard shad impingement (Figure 5). The high impingement rate of gizzard shad in the late fall and early winter may be related to its sensitivity to cold water temperatures (Trautman 1981, Becker 1983).

The pattern for freshwater drum impingement was similar to gizzard shad, i.e., high during the fall and winter and low during the spring and summer (Figure 6). However, the pattern for other species was less easy to describe. For example, impingement of bluegill and white bass varied erratically throughout the study (Figure 7). White bass had one major peak on 15 July when 26 percent of the annual total was impinged, but on the whole their catch was low during the summer. Bluegill impingement was frequently high in the period September through December, but exceptions were obvious.

Emerald shiner exhibited a late May to early summer peak that corresponds fairly well with their prespawning period (Figure 8). Skipjack herring were absent for the first six months of the study, showed a brief peak in mid-summer, and then declined rapidly (Figure 8). This pattern was noted during the previous study and is what one would expect given the seasonal migratory movements of this species (Trautman 1981, Pearson and Krumholz 1984).

Sauger and channel catfish had seasonal impingement patterns that were generally the opposite of each other. The impingement catch of sauger was highest during spring and lowest during the summer, whereas, the catch of channel catfish was highest during the summer and lowest during the spring (Figure 8). The temporal (seasonal) impingement patterns observed during this study for total catch were quite different than those reported during the previous impingement study at the Clifty Creek Station. For example, during the previous study, total catch (by number), and the numerical catch of both gizzard shad and freshwater drum was highest during midsummer, whereas, this was the period of lowest impingement during the present study (Figures 4-6). Similarly, the number of sauger impinged during the previous study was highest in the late summer and early fall, whereas, during the present study sauger impingement was lowest during this period (Figure 8). The catch of white bass was erratic during both studies, but major peaks occurred during mid-July in both studies, and in both studies white bass impingement was quite high in the early fall (Figure 7). The results of the two studies were that the impingement of skipjack herring is essentially restricted to mid-summer and early-fall (Figure 8).

3.3 LENGTH-FREQUENCY DISTRIBUTIONS

Length-frequency tables and figures were prepared for the four most abundant species and for sauger.

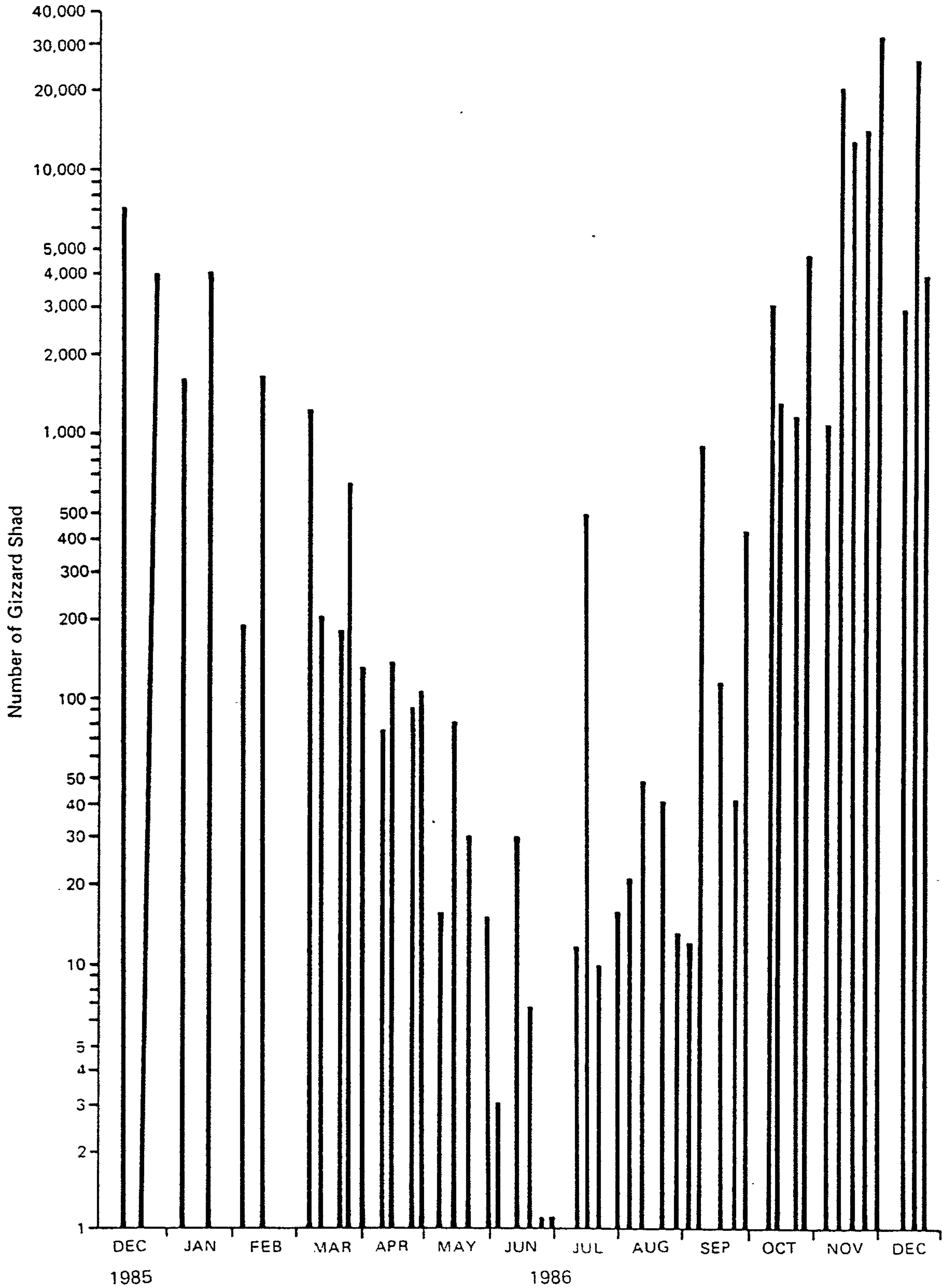

Figure 5. Number of gizzard shad impinged per sample at the Clifty Creek Station for the period December 1985 through December 1986.

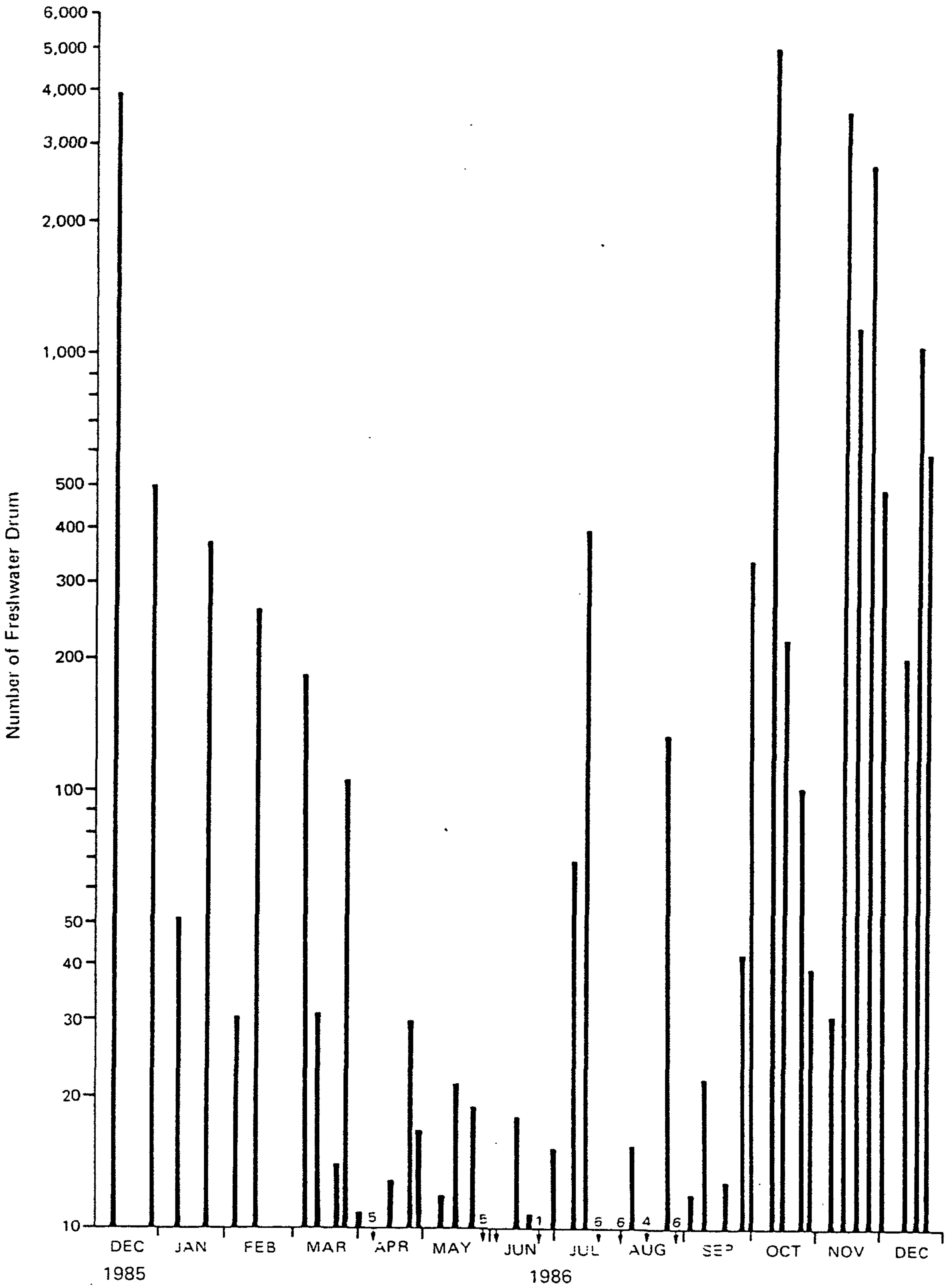

Figure 6. Number of freshwater drum impinged per sample at the Clifty Creek Station for the period December 1985 through December 1986.

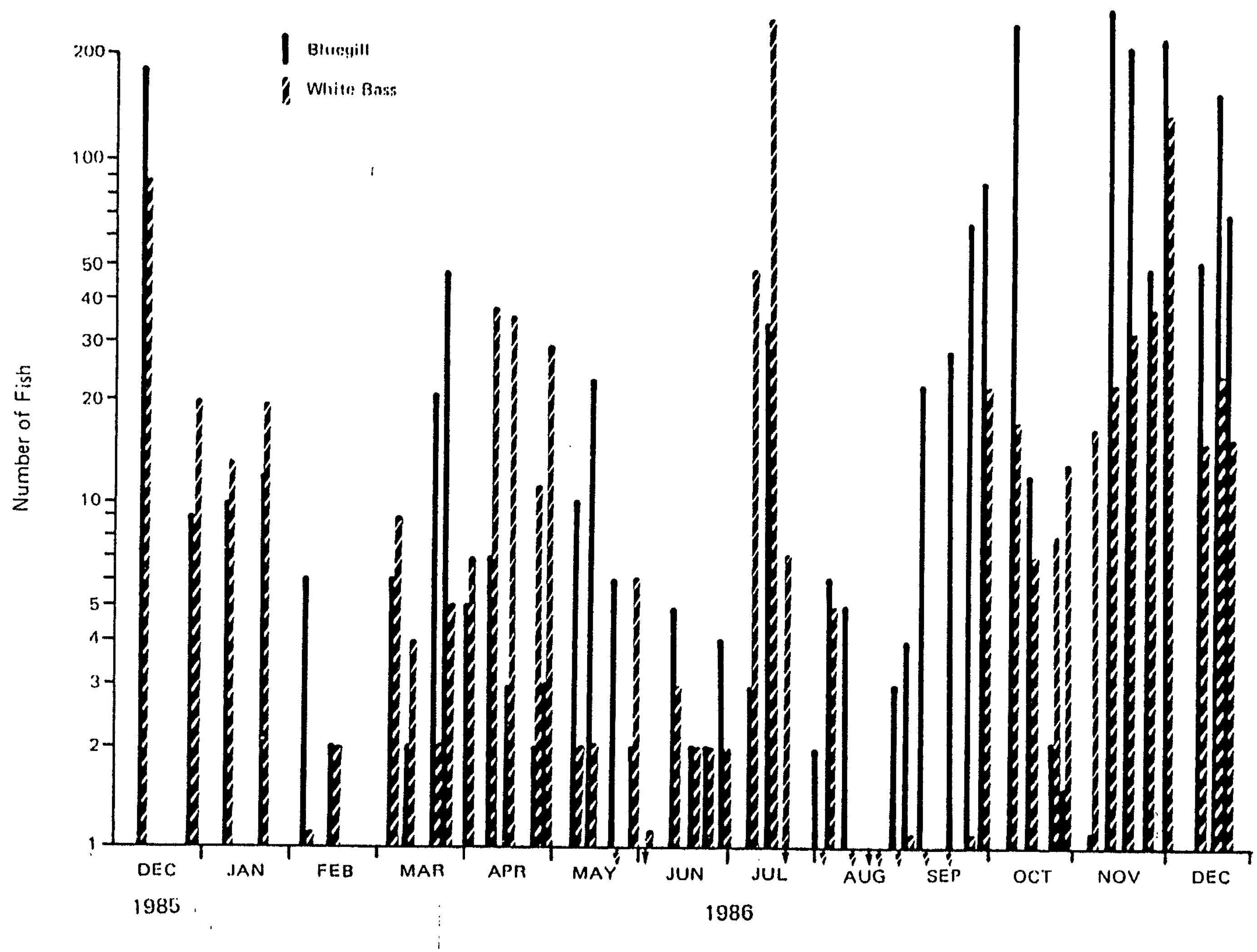

Figure 7. Numbers of bluegill and white bass impinged per sample at the Clifty Creek Station for the period December 1985 through December 1986.

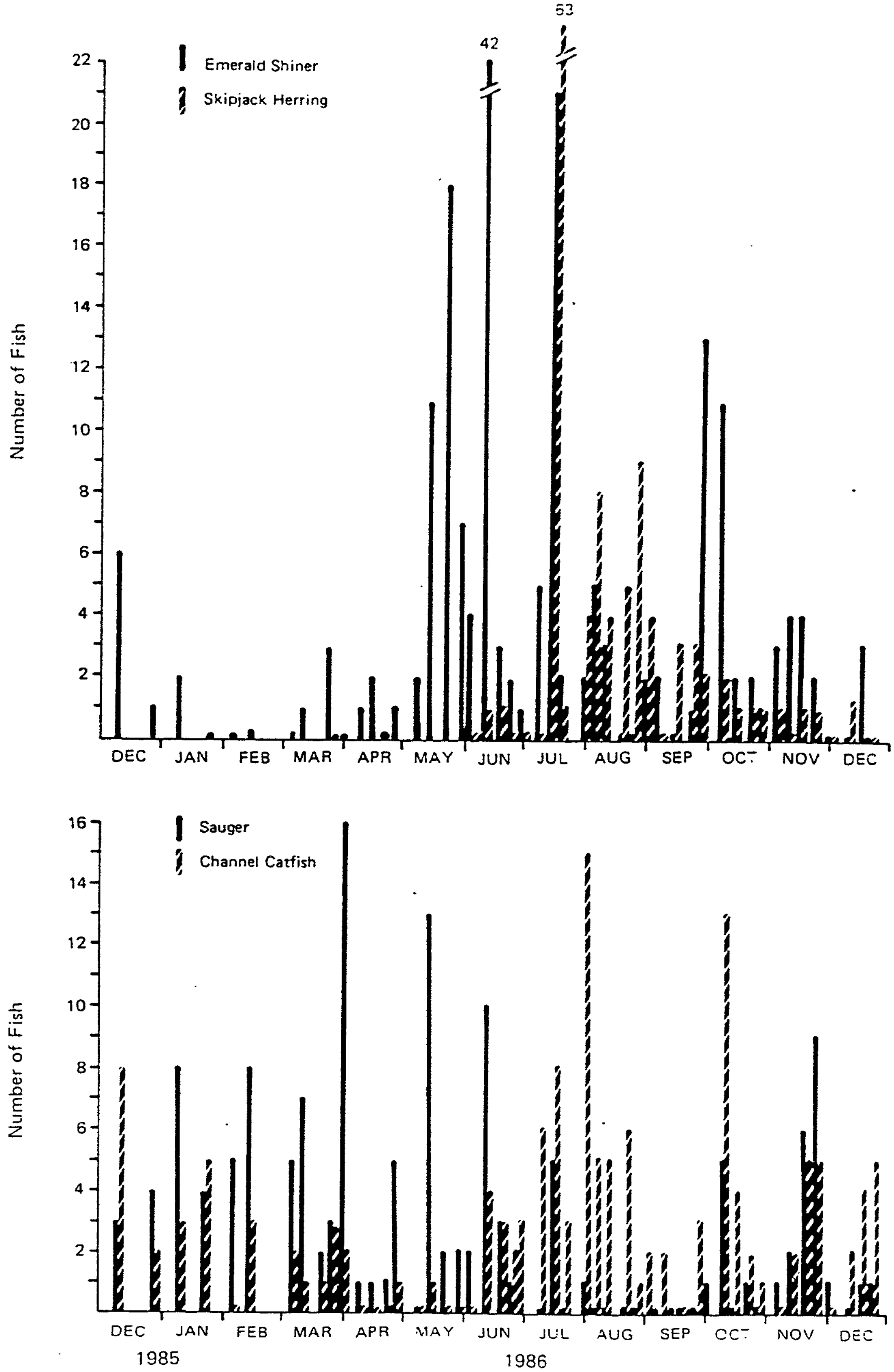

Figure 8. Numbers of emerald shiner, skipjack herring, sauger, and channel catfish impinged during the period December 1985 through December 1986.

Gizzard shad

Figure 9 shows that on an annual basis about 80 percent of the gizzard shad that were measured were less than 130 mm long. The proportion for all impinged gizzard shad is probably well above 90 percent because the subsample of measured gizzard shad contained proportionately more large shad.

On a monthly basis, the modal length of gizzard shad increased from 85 mm in December 1985 to 185 mm in June 1986 (Appendix B). This change probably represents a combination of growth of this year class as well as selective cropping of the smaller individuals. In July 1986, the modal length decreased to 85 mm where it remained throughout the remainder of the study (Appendix B). The change in July clearly reflects recruitment of the 1986 young-of-the-year (YOY) age class into the impingement catch, and subsequent "dilution" of the now much less numerous 1985 age class. It is also interesting that the modal length in December 1986 (85 mm) was the same as it had been in December 1985.

Freshwater drum

On an annual basis (Figure 10) approximately 90 percent of the freshwater drum had modal lengths <140 mm. Again, this percentage probably underestimates the actual percentage. Like gizzard shad, the modal length of freshwater drum in December 1985 was 85 mm and, as was the case with gizzard shad, the modal length increased for several months until it reached 125 mm in May 1986. Recruitment of YOY drum into the impingement catch occurred in June 1986 (Appendix B), one month earlier than YOY gizzard shad were recruited into the impingement catch. From June through October 1986, freshwater drum exhibited either a bimodal peak or a relatively broad range of lengths; both patterns indicating that the impingement catch was composed of a combination of YOYs and Age 1 drum (Appendix B). In November and December, the impingement catch was strongly dominated by YOY drum with a modal length each month of 85 mm. It is again interesting to note that the modal length in December 1986 of 85 mm is exactly the same as it had been one year earlier in December 1985.

Bluegill

The annual impingement catch of bluegill was strongly dominated (89 percent) by individuals <100 mm long (Figure 11). Furthermore, nearly two-thirds (64 percent) of the total catch was between 50 and 80 mm. Thus, the bluegill impingement catch was composed almost entirely of YOY and juvenile fish. Only 48 (3.5 percent) of the measured bluegills were large enough (>150 mm) to be considered "keepers" by the typical angler. All bluegills >150 mm in length collected during this study were measured.

White bass

Seven hundred twenty-one of the 925 white bass impinged during the study were measured, including all medium and large individuals. The length-frequency distribution of the measured individuals shows that two size (age) classes dominated the catch: about one-quarter of the catch was <100 mm, while about one-half the catch was between 100 and 150 mm (Figure 12). These two sizes

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FIGURE 9 SUMMARY OF LENGTH FREQUENCY (DEC 85 THROUGH DEC 86)

SPECIES=GIZZARD SHAD

FREQUENCY BAR CHART

```
MIDPOINT
 LENGTH   LENGTH (mm)                                                                            FREQ   CUM.   PERCENT    CUM.
                                                                                                        FREQ            PERCENT
          |
     5    |                                                                                         0      0     0.00      0.00
    15    |                                                                                         0      0     0.00      0.00
    25    |                                                                                         0      0     0.00      0.00
    35    |                                                                                         0      0     0.00      0.00
    45    |                                                                                         1      1     0.01      0.01
    55    |******                                                                                 111    112     1.65      1.67
    65    |*********                                                                              182    294     2.71      4.38
    75    |***********************************                                                    695    989    10.36     14.74
    85    |********************************************************************************      1591   2580    23.71     38.45
    95    |***************************************************************                       1254   3834    18.69     57.14
   105    |************************************                                                   714   4548    10.64     67.78
   115    |***********************                                                                451   4999     6.72     74.50
   125    |************                                                                           235   5234     3.50     78.00
   135    |******                                                                                 117   5351     1.74     79.75
   145    |****                                                                                    89   5440     1.33     81.07
   155    |**                                                                                      38   5478     0.57     81.64
   165    |*                                                                                       25   5503     0.37     82.01
   175    |**                                                                                      36   5539     0.54     82.55
   185    |***                                                                                     56   5595     0.83     83.38
   195    |*****                                                                                   91   5686     1.36     84.74
   205    |*****                                                                                  109   5795     1.62     86.36
   215    |****                                                                                    88   5883     1.31     87.68
   225    |****                                                                                    70   5953     1.04     88.72
   235    |****                                                                                    85   6038     1.27     89.99
   245    |****                                                                                    78   6116     1.16     91.15
   255    |****                                                                                    85   6201     1.27     92.41
   265    |****                                                                                    89   6290     1.33     93.74
   275    |*****                                                                                  109   6399     1.62     95.37
   285    |****                                                                                    79   6478     1.18     96.54
   295    |****                                                                                    70   6548     1.04     97.59
   305    |***                                                                                     51   6599     0.76     98.35
   315    |**                                                                                      44   6643     0.66     99.00
   325    |**                                                                                      32   6675     0.48     99.48
   335    |*                                                                                       14   6689     0.21     99.69
   345    |*                                                                                       10   6699     0.15     99.84
   355    |                                                                                         7   6706     0.10     99.94
   365    |                                                                                         1   6707     0.01     99.96
   375    |                                                                                         0   6707     0.00     99.96
   385    |                                                                                         1   6708     0.01     99.97
   395    |                                                                                         2   6710     0.03    100.00
          -----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
              100  200  300  400  500  600  700  800  900 1000 1100 1200 1300 1400 1500 1600

                                             FREQUENCY
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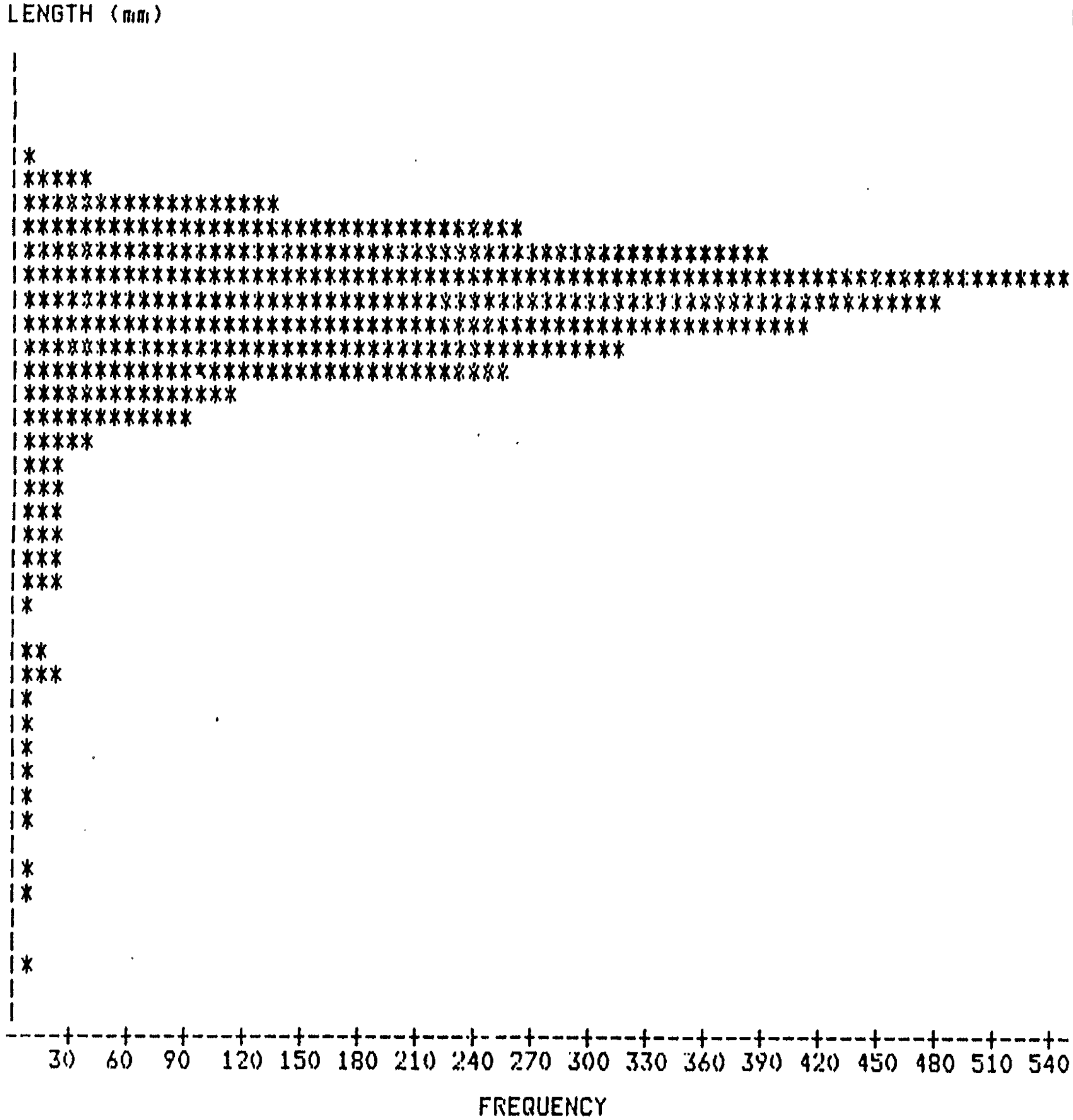
FIGURE 10 SUMMARY OF LENGTH FREQUENCY (DEC 85 THROUGH DEC 86)

SPECIES=FRESHWATER DRUM

FREQUENCY BAR CHART



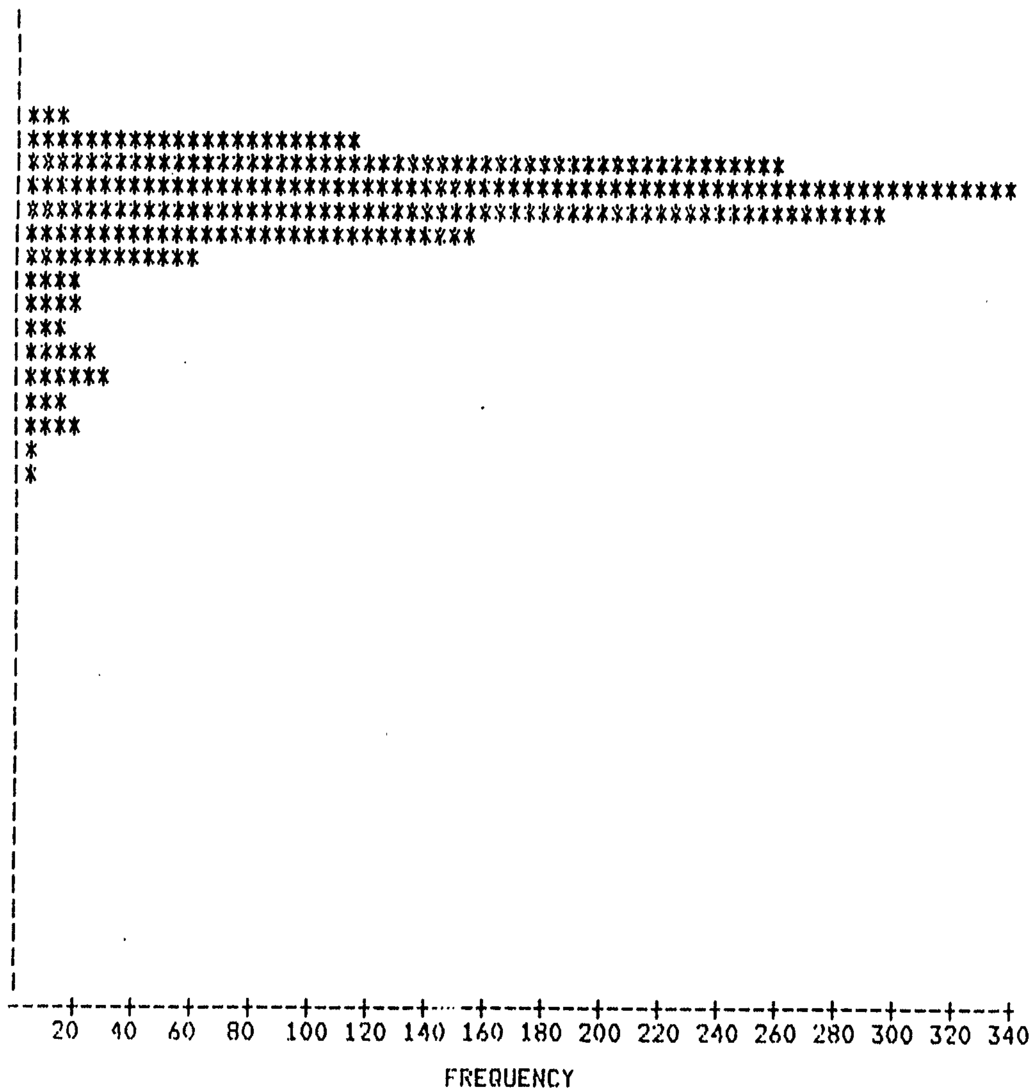
MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
5	0	0	0.00	0.00
15	1	1	0.03	0.03
25	1	2	0.03	0.06
35	4	6	0.12	0.18
45	35	41	1.06	1.24
55	133	174	4.02	5.26
65	261	435	7.89	13.14
75	390	825	11.78	24.92
85	546	1371	16.50	41.42
95	481	1852	14.53	55.95
105	410	2262	12.39	68.34
115	317	2579	9.58	77.92
125	253	2832	7.64	85.56
135	115	2947	3.47	89.03
145	89	3036	2.69	91.72
155	34	3070	1.03	92.75
165	23	3093	0.69	93.44
175	19	3112	0.57	94.02
185	20	3132	0.60	94.62
195	20	3152	0.60	95.23
205	19	3171	0.57	95.80
215	20	3191	0.60	96.40
225	7	3198	0.21	96.62
235	3	3201	0.09	96.71
245	14	3215	0.42	97.13
255	22	3237	0.66	97.79
265	10	3247	0.30	98.10
275	11	3258	0.33	98.43
285	8	3266	0.24	98.67
295	9	3275	0.27	98.94
305	9	3284	0.27	99.21
315	4	3288	0.12	99.34
325	3	3291	0.09	99.43
335	5	3296	0.15	99.58
345	6	3302	0.18	99.76
355	3	3305	0.09	99.85
365	0	3305	0.00	99.85
375	4	3309	0.12	99.97
385	0	3309	0.00	99.97
395	1	3310	0.03	100.00

INDIANA-KENTUCKY ELECTRIC CORP - CLIFTY CREEK STATION
DEC 1985 - DEC 1986 IMPINGEMENT DATA

FIGURE 11 SUMMARY OF LENGTH FREQUENCY (DEC 85 THROUGH DEC 86)

SPECIES=BLUEGILL

FREQUENCY BAR CHART

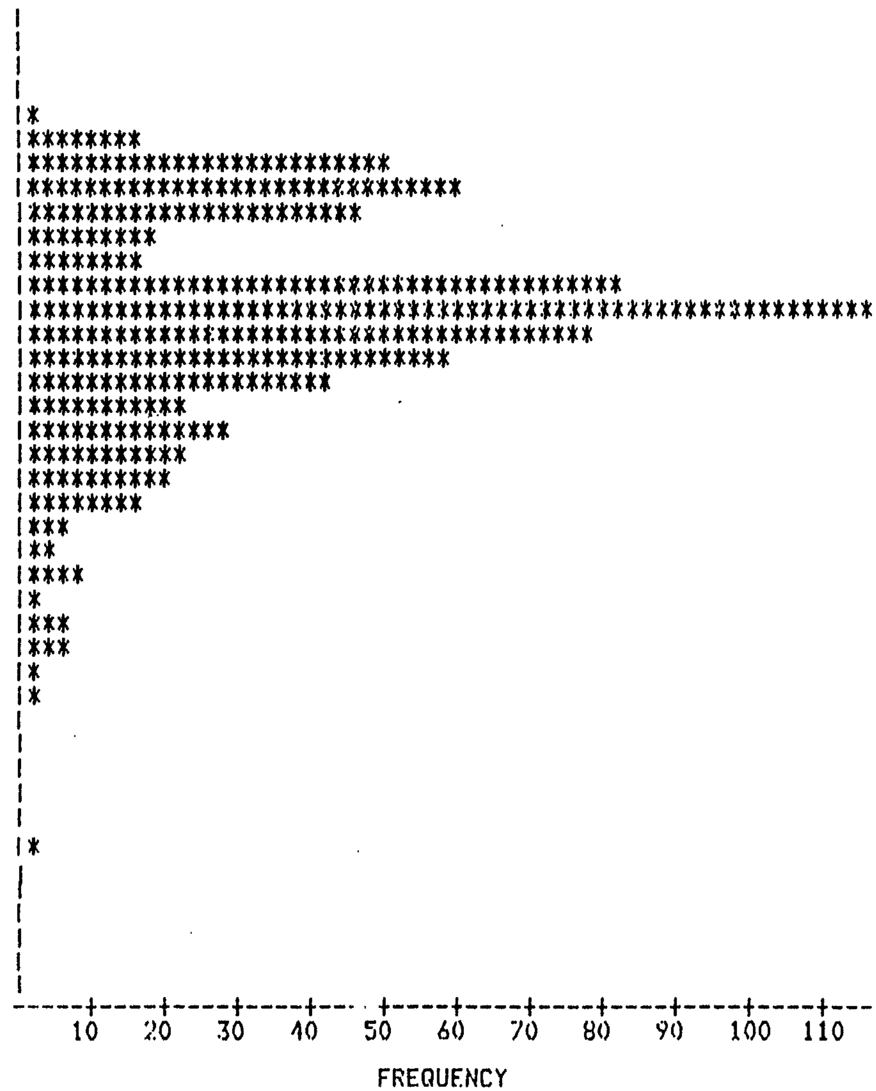


MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
5	0	0	0.00	0.00
15	0	0	0.00	0.00
25	2	2	0.14	0.14
35	17	19	1.22	1.37
45	116	135	8.34	9.71
55	258	393	18.55	28.25
65	338	731	24.30	52.55
75	295	1026	21.21	73.76
85	154	1180	11.07	84.83
95	58	1238	4.17	89.00
105	20	1258	1.44	90.44
115	19	1277	1.37	91.80
125	13	1290	0.93	92.74
135	25	1315	1.80	94.54
145	28	1343	2.01	96.55
155	13	1356	0.93	97.48
165	21	1377	1.51	98.99
175	6	1383	0.43	99.42
185	4	1387	0.29	99.71
195	2	1389	0.14	99.86
205	1	1390	0.07	99.93
215	0	1390	0.00	99.93
225	0	1390	0.00	99.93
235	0	1390	0.00	99.93
245	0	1390	0.00	99.93
255	0	1390	0.00	99.93
265	0	1390	0.00	99.93
275	1	1391	0.07	100.00
285	0	1391	0.00	100.00
295	0	1391	0.00	100.00
305	0	1391	0.00	100.00
315	0	1391	0.00	100.00
325	0	1391	0.00	100.00
335	0	1391	0.00	100.00
345	0	1391	0.00	100.00
355	0	1391	0.00	100.00
365	0	1391	0.00	100.00
375	0	1391	0.00	100.00
385	0	1391	0.00	100.00
395	0	1391	0.00	100.00

FIGURE 12 SUMMARY OF LENGTH FREQUENCY (DEC 85 THROUGH DEC 86)

SPECIES=WHITE BASS

FREQUENCY BAR CHART



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
5	0	0	0.00	0.00
15	0	0	0.00	0.00
25	0	0	0.00	0.00
35	1	1	0.14	0.14
45	16	17	2.22	2.36
55	50	67	6.93	9.29
65	60	127	8.32	17.61
75	45	172	6.24	23.86
85	18	190	2.50	26.35
95	16	206	2.22	28.57
105	82	288	11.37	39.94
115	116	404	16.09	56.03
125	78	482	10.82	66.85
135	58	540	8.04	74.90
145	42	582	5.83	80.72
155	21	603	2.91	83.63
165	27	630	3.74	87.38
175	22	652	3.05	90.43
185	19	671	2.64	93.07
195	15	686	2.08	95.15
205	6	692	0.83	95.98
215	4	696	0.55	96.53
225	8	704	1.11	97.64
235	2	706	0.28	97.92
245	6	712	0.83	98.75
255	5	717	0.69	99.45
265	2	719	0.28	99.72
275	1	720	0.14	99.86
285	0	720	0.00	99.86
295	0	720	0.00	99.86
305	0	720	0.00	99.86
315	0	720	0.00	99.86
325	0	720	0.00	99.86
335	1	721	0.14	100.00
345	0	721	0.00	100.00
355	0	721	0.00	100.00
365	0	721	0.00	100.00
375	0	721	0.00	100.00
385	0	721	0.00	100.00
395	0	721	0.00	100.00

represent YOY and Age I fish, respectively (Becker 1983). Only 19 percent of the catch was larger than 150 mm and only 4 percent (35 individuals) was larger than 200 mm (8 inches), the size at which they would typically enter the sports' creel.

Sauger

All of the 139 sauger impinged during the study were measured (Figure 13). These data indicate that only 5 percent of the sauger impinged were YOYs. They also show that the largest number of individuals (63 percent) were between 200 and 300 mm, and therefore were probably Age I or Age II fish (Becker 1983). Twenty-one percent (29 individuals) of the sauger collected were larger than 300 mm.

3.4 STATISTICAL ANALYSIS

The Spearman and Pearson correlation analyses showed that river stage and intake temperature were statistically correlated with total catch and the catch of each of the four most abundantly collected species (Table 4). The Spearman test indicated that total catch and the catch of gizzard shad and freshwater drum were significantly correlated with median intake velocity, whereas, the catch of bluegill and white bass was not significantly correlated with median intake velocity (Table 4). The Pearson test indicated that catch was not significantly correlated with median velocity for any species or for total catch.

River Stage

Both tests indicated that river stage was directly correlated with impingement catch for all species considered (Table 4). That is, as river stage (flow) increased so did the impingement of total fish, gizzard shad, drum, bluegill, and white bass. Both methods indicated that the correlation between river stage and impingement catch was strongest for total catch and catch of gizzard shad (as one would expect given the fact gizzard shad dominated the total catch) and weakest for white bass.

Intake Temperature

Both tests indicated that the relationship between intake temperature and catch was inverse (Table 4). That is, as temperature increased, impingement catch generally decreased. The Spearman test indicated that this inverse relationship was statistically significant for all the comparisons that were made. The correlation was particularly strong (-0.75) for gizzard shad (Table 4). The Pearson test, however, indicated that the relationship was statistically significant only for total catch and gizzard shad catch.

Median Velocity

Again, both tests indicated that the relationship between median velocity and impingement catch was inverse. However, the significance of this relationship

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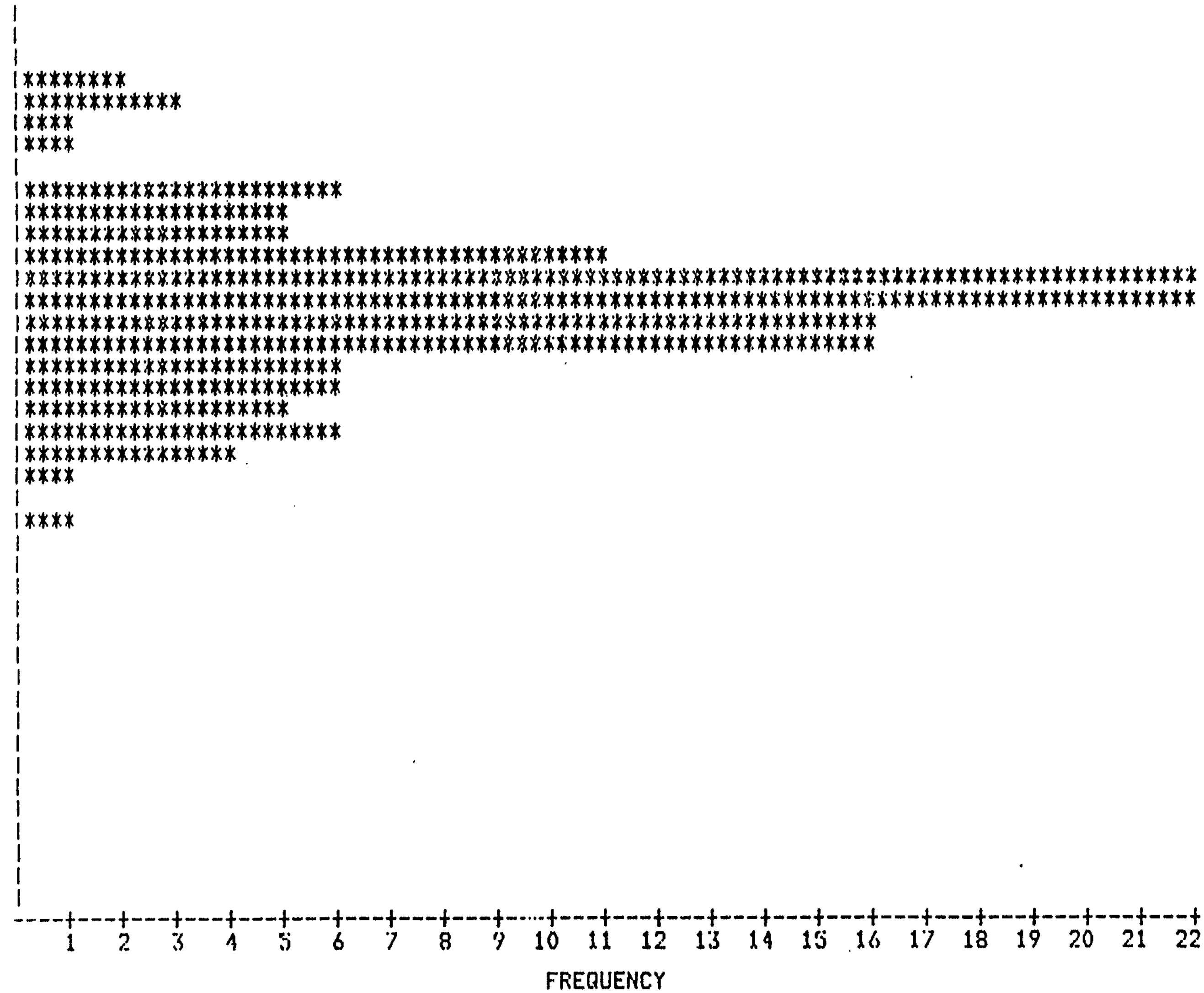
FIGURE 13 SUMMARY OF LENGTH FREQUENCY (DEC 85 THROUGH DEC 86)

SPECIES=SAUGER

FREQUENCY BAR CHART



MIDPOINT LENGTH	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
10	0	0	0.00	0.00
30	0	0	0.00	0.00
50	2	2	1.44	1.44
70	3	5	2.16	3.60
90	1	6	0.72	4.32
110	1	7	0.72	5.04
130	0	7	0.00	5.04
150	6	13	4.32	9.35
170	5	18	3.60	12.95
190	5	23	3.60	16.55
210	11	34	7.91	24.46
230	22	56	15.83	40.29
250	22	78	15.83	56.12
270	16	94	11.51	67.63
290	16	110	11.51	79.14
310	6	116	4.32	83.45
330	6	122	4.32	87.77
350	5	127	3.60	91.37
370	6	133	4.32	95.68
390	4	137	2.88	98.56
410	1	138	0.72	99.28
430	0	138	0.00	99.28
450	1	139	0.72	100.00
470	0	139	0.00	100.00
490	0	139	0.00	100.00
510	0	139	0.00	100.00
530	0	139	0.00	100.00
550	0	139	0.00	100.00
570	0	139	0.00	100.00
590	0	139	0.00	100.00
610	0	139	0.00	100.00
630	0	139	0.00	100.00
650	0	139	0.00	100.00
670	0	139	0.00	100.00
690	0	139	0.00	100.00
710	0	139	0.00	100.00
730	0	139	0.00	100.00
750	0	139	0.00	100.00
770	0	139	0.00	100.00
790	0	139	0.00	100.00

TABLE 4 CORRELATION ANALYSIS BETWEEN IMPINGEMENT CATCH AND THREE PHYSICAL VARIABLES USING TWO STATISTICAL TESTS

	River Stage		Intake Temperature		Median Velocity	
	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson
Total Catch						
CC[1]	.58	.45	-.70	-.37	-.38	-.24
SS[2]	.0001	.001	.0001	.009	.013	.133
N[3]	49	49	49	49	41	41
Gizzard Shad						
CC	.57	.43	-.75	-.37	-.40	-.23
SS	.0001	.002	.0001	.009	.010	.143
N	49	49	49	49	41	41
Drum						
CC	.62	.37	-.53	-.20	-.32	-.20
SS	.0001	.009	.0001	.176	.040	.214
N	49	49	49	49	41	41
Bluegill						
CC	.46	.42	-.36	-.24	-.24	-.17
SS	.0009	.003	.010	.099	.126	.274
N	49	49	49	49	41	41
White bass						
CC	.43	.28	-.44	-.05	-.18	-.18
SS	.002	.050	.001	.710	.273	.269
N	49	49	49	49	41	41

[1]CC = Correlation coefficient.
[2]SS = Statistical significance level; values ≤ 0.05 are considered significant.
[3]N = Number of observations.

was weak at best. The Spearman test showed the relationship to be statistically significant only for total catch, catch of gizzard shad, and catch of drum. The Pearson test indicated that none of the apparent correlations were statistically significant.

Collectively, the above results suggest that impingement catch is strongly, and directly, correlated with river stage, moderately (and inversely) correlated with intake (river) temperature, and is correlated weakly, if at all, with intake velocity. It should also be recognized that even though the correlations may be significant, their predictive value is only qualitative. Plots of the three physical parameters versus catch statistics revealed a large amount of scatter (i.e., variance is high). Thus, one can reasonably say that low temperatures and high river flows usually result in high impingement catches, or that high temperatures and low flows usually result in low impingement catches. However, it would not be possible (or appropriate) to predict with any degree of precision what the actual total catch (or catch by species) would be for a specific intake temperature and river stage. It is possible, however, to predict trends in impingement rates based on water temperature.

3.5 ANNUAL IMPINGEMENT ESTIMATES

Impingement estimates for total catch and by taxa were derived for the entire 13-month study (Table 5) and for two 12-month periods: December 1985 through November 1986 (Table 6) and January 1986 through December 1986 (Table 7). These data for total catch and for several important species are summarized in Table 8. Annual and monthly estimates for each of the three time periods are included in Appendix B. Annual estimates for total catch and selected important species are: total fish - about one million; gizzard shad - 0.73 to 1.03 million, drum - about 130-180 thousand; bluegill - about 12,000; white bass - about 6500, sauger - about 1000, and skipjack herring - about 1000 (Table 8). For most species, the annual estimates derived from the two recent 12-month periods are comparable (Tables 5-8) indicating that for most species the catch in December of 1985 was comparable to that in December of 1986. However, the estimated annual impingement of gizzard shad increases by 41 percent if December 1986 is part of the 12-month period, whereas the estimated catch of freshwater drum drops by 28 percent under the same circumstances (Table 8).

Examination of Table 8 reveals that the annual estimates in 1977-78 of total fish impinged as well as estimates for gizzard shad and white bass are about double the number estimated for either of the recent 12-month periods. The estimated number of impinged sauger has dropped by 11-fold while the estimated number of impinged skipjack herring has declined by more than 200-fold. Estimated bluegill impingement has increased slightly, while the recent estimates for freshwater drum have approximately doubled. Estimated channel catfish impingement has decreased slightly. Collectively, the estimates show that the Clifty Creek Station is currently impinging only about one-half the number of fish and less than one-half the biomass it did during the previous study period.

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TABLE 5 ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
SILVER LAMPREY	1	0.00	80	0.01	7	0.00	560	0.00
PADDLEFISH	18	0.01	2530	0.17	158	0.01	27702	0.23
LONGNOSE GAR	12	0.01	3085	0.21	100	0.01	23515	0.20
SKIPJACK HERRING	117	0.07	4185	0.29	819	0.06	29295	0.25
GIZZARD SHAD	149089	84.87	1116774	76.51	1194207	83.73	8928690	74.86
THREADFIN SHAD	25	0.01	131	0.01	199	0.01	1053	0.01
GOLDEYE	3	0.00	960	0.07	21	0.00	6720	0.06
MOONEYE	68	0.04	6073	0.42	636	0.04	62319	0.52
RAINBOW SMELT	1	0.00	2	0.00	7	0.00	14	0.00
GOLDFISH	1	0.00	3	0.00	7	0.00	21	0.00
CARP	32	0.02	533	0.04	296	0.02	4107	0.03
GOLDEN SHINER	11	0.01	135	0.01	85	0.01	1001	0.01
FATHEAD MINNOW	3	0.00	14	0.00	21	0.00	98	0.00
CREEK CHUB	2	0.00	61	0.00	14	0.00	427	0.00
SPOTFIN SHINER	4	0.00	4	0.00	28	0.00	28	0.00
EMERALD SHINER	197	0.11	917	0.06	1451	0.10	6379	0.06
CENTRAL STONEROLLER	1	0.00	11	0.00	7	0.00	77	0.00
MIMIC SHINER	8	0.00	10	0.00	64	0.00	78	0.00
SAND SHINER	1	0.00	3	0.00	7	0.00	21	0.00
RIVER SHINER	5	0.00	16	0.00	59	0.00	184	0.00
SILVER CHUB	57	0.03	1165	0.08	559	0.04	11667	0.10

(CONTINUED)

TABLE 5 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
UNID SHINER	4	0.00	4	0.00	28	0.00	28	0.00
RIVER CARPSUCKER	3	0.00	2590	0.18	29	0.00	24690	0.21
QUILLBACK	50	0.03	5291	0.36	550	0.04	49173	0.41
WHITE SUCKER	11	0.01	144	0.01	77	0.01	1008	0.01
UNID SUCKER	2	0.00	4	0.00	14	0.00	28	0.00
NORTHERN HOG SUCKER	1	0.00	17	0.00	7	0.00	119	0.00
SMALLMOUTH BUFFALO	14	0.01	7101	0.49	162	0.01	58427	0.49
SPOTTED SUCKER	5	0.00	46	0.00	43	0.00	370	0.00
SILVER REDHORSE	2	0.00	557	0.04	14	0.00	3899	0.03
GOLDEN REDHORSE	2	0.00	715	0.05	22	0.00	5043	0.04
SHORTHEAD REDHORSE	5	0.00	1742	0.12	35	0.00	12194	0.10
CARPSUCKER X BUFFALO	1	0.00	1	0.00	15	0.00	15	0.00
UNID REDHORSE	1	0.00	8	0.00	7	0.00	56	0.00
BLUE CATFISH	6	0.00	69	0.00	42	0.00	483	0.00
BLACK BULLHEAD	6	0.00	275	0.02	66	0.00	2581	0.02
CHANNEL CATFISH	144	0.08	5286	0.36	1176	0.08	39914	0.33
STONECAT	1	0.00	4	0.00	7	0.00	28	0.00
FLATHEAD CATFISH	22	0.01	1051	0.07	178	0.01	7509	0.06
WHITE BASS	975	0.56	21214	1.45	7977	0.56	190914	1.60
STRIPED BASS	30	0.02	2052	0.14	314	0.02	27020	0.23
HYBRID BASS	7	0.00	1247	0.09	49	0.00	8729	0.07

(CONTINUED)

INDIANA-KENTUCKY ELECTRIC CORP - CLIFTY CREEK STATION
DEC 1985 - DEC 1986 IMPINGEMENT DATA

TABLE 5 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
ROCKBASS	4	0.00	21	0.00	28	0.00	147	0.00
GREEN SUNFISH	5	0.00	48	0.00	35	0.00	336	0.00
WARMOUTH	49	0.03	1165	0.08	407	0.03	9643	0.08
BLUEGILL	1923	1.09	19081	1.31	15229	1.07	144279	1.21
LONGEAR SUNFISH	35	0.02	1494	0.10	285	0.02	10922	0.09
SPOTTED BASS	1	0.00	255	0.02	7	0.00	1785	0.01
LARGEMOUTH BASS	30	0.02	1228	0.08	242	0.02	14628	0.12
WHITE CRAPPIE	49	0.03	1458	0.10	375	0.03	14294	0.12
BLACK CRAPPIE	38	0.02	1919	0.13	266	0.02	13433	0.11
UNID SUNFISH	15	0.01	165	0.01	105	0.01	1155	0.01
HYBRID SUNFISH	12	0.01	193	0.01	116	0.01	1759	0.01
SAUGER	139	0.08	22089	1.51	1229	0.09	215439	1.81
RIVER DARTER	8	0.00	43	0.00	56	0.00	301	0.00
YELLOW PERCH	3	0.00	108	0.01	29	0.00	780	0.01
WALLEYE	35	0.02	438	0.03	253	0.02	4218	0.04
LOGPERCH	8	0.00	136	0.01	56	0.00	952	0.01
FRESHWATER DRUM	22357	12.73	223668	15.32	197939	13.88	1957068	16.41
TOTAL FISH	175659	100.00	1459619	100.00	1426221	100.00	11927525	100.00

TABLE 6 ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH NOV 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
SILVER LAMPREY	1	0.00	80	0.01	7	0.00	560	0.01
PADDLEFISH	17	0.02	2513	0.26	151	0.02	27583	0.32
LONGNOSE GAR	11	0.01	2110	0.22	93	0.01	16690	0.19
SKIPJACK HERRING	116	0.11	4182	0.43	812	0.09	29274	0.34
GIZZARD SHAD	82423	77.88	677118	69.17	727545	77.61	5851098	68.33
THREADFIN SHAD	23	0.02	108	0.01	185	0.02	892	0.01
GOLDEYE	1	0.00	450	0.05	7	0.00	3150	0.04
MOONEYE	46	0.04	4835	0.49	482	0.05	53653	0.63
RAINBOW SMELT	1	0.00	2	0.00	7	0.00	14	0.00
GOLDFISH	1	0.00	3	0.00	7	0.00	21	0.00
CARP	31	0.03	522	0.05	289	0.03	4030	0.05
GOLDEN SHINER	11	0.01	135	0.01	85	0.01	1001	0.01
FATHEAD MINNOW	3	0.00	14	0.00	21	0.00	98	0.00
CREEK CHUB	2	0.00	61	0.01	14	0.00	427	0.00
SPOTFIN SHINER	4	0.00	4	0.00	28	0.00	28	0.00
EMERALD SHINER	194	0.18	897	0.09	1430	0.15	6439	0.08
CENTRAL STONEROLLER	1	0.00	11	0.00	7	0.00	77	0.00
MIMIC SHINER	8	0.01	10	0.00	64	0.01	78	0.00
SAND SHINER	1	0.00	3	0.00	7	0.00	21	0.00
RIVER SHINER	5	0.00	16	0.00	59	0.01	184	0.00
SILVER CHUB	57	0.05	1165	0.12	559	0.06	11667	0.14

(CONTINUED)

INDIANA-KENTUCKY ELECTRIC CORP - CLIFTY CREEK STATION
DEC 1985 - DEC 1986 IMPINGEMENT DATA

TABLE 6 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH NOV 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
UNID SHINER	4	0.00	4	0.00	28	0.00	28	0.00
RIVER CARPSUCKER	2	0.00	1390	0.14	22	0.00	16290	0.19
QUILLBACK	42	0.04	5195	0.53	494	0.05	48501	0.57
WHITE SUCKER	11	0.01	144	0.01	77	0.01	1008	0.01
UNID SUCKER	2	0.00	4	0.00	14	0.00	28	0.00
NORTHERN HOG SUCKER	1	0.00	17	0.00	7	0.00	119	0.00
SMALLMOUTH BUFFALO	11	0.01	2221	0.23	141	0.02	24267	0.28
SPOTTED SUCKER	1	0.00	6	0.00	15	0.00	90	0.00
SILVER REDHORSE	2	0.00	557	0.06	14	0.00	3899	0.05
GOLDEN REDHORSE	2	0.00	715	0.07	22	0.00	5045	0.06
SHORTHEAD REDHORSE	5	0.00	1742	0.18	35	0.00	12194	0.14
CARPSUCKER X BUFFALO	1	0.00	1	0.00	15	0.00	15	0.00
UNID REDHORSE	1	0.00	8	0.00	7	0.00	56	0.00
BLUE CATFISH	6	0.01	69	0.01	42	0.00	483	0.01
BLACK BULLHEAD	6	0.01	275	0.03	66	0.01	2581	0.03
CHANNEL CATFISH	133	0.13	5205	0.53	1099	0.12	39347	0.46
STONECAT	1	0.00	4	0.00	7	0.00	28	0.00
FLATHEAD CATFISH	21	0.02	1047	0.11	171	0.02	7481	0.09
WHITE BASS	787	0.74	18277	1.87	6661	0.71	170355	1.99
STRIPED BASS	28	0.03	2038	0.21	300	0.03	26922	0.31
HYBRID BASS	5	0.00	1198	0.12	35	0.00	8386	0.10

(CONTINUED)

TABLE 6 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: DEC 1985 THROUGH NOV 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
ROCKBASS	3	0.00	13	0.00	21	0.00	91	0.00
GREEN SUNFISH	5	0.00	48	0.00	35	0.00	336	0.00
WARMOUTH	43	0.04	1137	0.12	365	0.04	9447	0.11
BLUEGILL	1432	1.35	15464	1.58	11792	1.26	118960	1.39
LONGEAR SUNFISH	35	0.03	1494	0.15	285	0.03	10922	0.13
SPOTTED BASS	1	0.00	255	0.03	7	0.00	1785	0.02
LARGEMOUTH BASS	21	0.02	1134	0.12	179	0.02	13970	0.16
WHITE CRAPPIE	28	0.03	1331	0.14	228	0.02	13405	0.16
BLACK CRAPPIE	29	0.03	1798	0.18	203	0.02	12586	0.15
UNID SUNFISH	15	0.01	165	0.02	105	0.01	1155	0.01
HYBRID SUNFISH	9	0.01	130	0.01	95	0.01	1318	0.02
SAUGER	136	0.13	21654	2.21	1208	0.13	212394	2.48
RIVER DARTER	8	0.01	43	0.00	56	0.01	301	0.00
YELLOW PERCH	3	0.00	108	0.01	29	0.00	780	0.01
WALLEYE	35	0.03	438	0.04	253	0.03	4218	0.05
LOGPERCH	8	0.01	136	0.01	56	0.01	952	0.01
FRESHWATER DRUM	19995	18.89	199236	20.35	181405	19.35	1786044	20.86
TOTAL FISH	105835	100.00	978940	100.00	937453	100.00	8562772	100.00

TABLE 7 ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: JAN 1986 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
SILVER LAMPREY	1	0.00	80	0.01	7	0.00	560	0.01
PADDLEFISH	16	0.01	1345	0.10	128	0.01	9927	0.10
LONGNOSE GAR	11	0.01	2845	0.21	85	0.01	19915	0.20
SKIPJACK HERRING	117	0.07	4185	0.31	819	0.07	29295	0.29
GIZZARD SHAD	137933	86.40	1045098	78.31	1026867	86.58	7853550	78.13
THREADFIN SHAD	22	0.01	114	0.01	154	0.01	798	0.01
GOLDEYE	3	0.00	960	0.07	21	0.00	6720	0.07
MOONEYE	60	0.04	5045	0.38	516	0.04	46899	0.47
RAINBOW SMELT	1	0.00	2	0.00	7	0.00	14	0.00
GOLDFISH	1	0.00	3	0.00	7	0.00	21	0.00
CARP	27	0.02	507	0.04	221	0.02	3717	0.04
GOLDEN SHINER	11	0.01	135	0.01	85	0.01	1001	0.01
FATHEAD MINNOW	3	0.00	14	0.00	21	0.00	98	0.00
CREEK CHUB	2	0.00	61	0.00	14	0.00	427	0.00
SPOTFIN SHINER	4	0.00	4	0.00	28	0.00	28	0.00
EMERALD SHINER	190	0.12	904	0.07	1346	0.11	6384	0.06
CENTRAL STONEROLLER	1	0.00	11	0.00	7	0.00	77	0.00
MIMIC SHINER	7	0.00	9	0.00	49	0.00	63	0.00
SAND SHINER	1	0.00	3	0.00	7	0.00	21	0.00
RIVER SHINER	3	0.00	10	0.00	29	0.00	94	0.00
SILVER CHUB	51	0.03	1059	0.08	469	0.04	10077	0.10

(CONTINUED)

TABLE 7 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: JAN 1986 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
UNID SHINER	4	0.00	4	0.00	28	0.00	28	0.00
RIVER CARPSUCKER	2	0.00	1770	0.13	14	0.00	12390	0.12
QUILLBACK	28	0.02	4439	0.33	220	0.02	36393	0.36
WHITE SUCKER	11	0.01	144	0.01	77	0.01	1008	0.01
UNID SUCKER	2	0.00	4	0.00	14	0.00	28	0.00
NORTHERN HOG SUCKER	1	0.00	17	0.00	7	0.00	119	0.00
SMALLMOUTH BUFFALO	11	0.01	6088	0.46	117	0.01	43232	0.43
SPOTTED SUCKER	5	0.00	46	0.00	43	0.00	370	0.00
SILVER REDHORSE	2	0.00	557	0.04	14	0.00	3899	0.04
GOLDEN REDHORSE	1	0.00	710	0.05	7	0.00	4970	0.05
SHORTHEAD REDHORSE	5	0.00	1742	0.13	35	0.00	12194	0.12
CARPSUCKER X BUFFALO	1	0.00	1	0.00	15	0.00	15	0.00
UNID REDHORSE	1	0.00	8	0.00	7	0.00	56	0.00
BLUE CATFISH	6	0.00	69	0.01	42	0.00	483	0.00
BLACK BULLHEAD	4	0.00	247	0.02	36	0.00	2161	0.02
CHANNEL CATFISH	134	0.08	5103	0.38	1026	0.09	37169	0.37
STONECAT	1	0.00	4	0.00	7	0.00	28	0.00
FLATHEAD CATFISH	20	0.01	1037	0.08	148	0.01	7299	0.07
WHITE BASS	867	0.54	17861	1.34	6357	0.54	140619	1.40
STRIPED BASS	24	0.02	725	0.05	224	0.02	7115	0.07
HYBRID BASS	7	0.00	1247	0.09	49	0.00	8729	0.09

(CONTINUED)

INDIANA-KENTUCKY ELECTRIC CORP - CLIFTY CREEK STATION
DEC 1985 - DEC 1986 IMPINGEMENT DATA

TABLE 7 (CONT) ANNUAL IMPINGEMENT ESTIMATES

EXPANSION PERIOD: JAN 1986 THROUGH DEC 1986

	NUMBER CAUGHT		WEIGHT CAUGHT		EXPANDED NUMBER		EXPANDED WEIGHT	
	#	%	GRAMS	%	#	%	GRAMS	%
SPECIES								
ROCKBASS	4	0.00	21	0.00	28	0.00	147	0.00
GREEN SUNFISH	5	0.00	48	0.00	35	0.00	336	0.00
WARMOUTH	42	0.03	1032	0.08	302	0.03	7648	0.08
BLUEGILL	1732	1.08	17857	1.34	12364	1.04	125919	1.25
LONGEAR SUNFISH	32	0.02	1487	0.11	240	0.02	10817	0.11
SPOTTED BASS	1	0.00	255	0.02	7	0.00	1785	0.02
LARGEMOUTH BASS	29	0.02	1078	0.08	227	0.02	12378	0.12
WHITE CRAPPIE	47	0.03	1453	0.11	345	0.03	14219	0.14
BLACK CRAPPIE	38	0.02	1919	0.14	266	0.02	13433	0.13
UNID SUNFISH	15	0.01	165	0.01	105	0.01	1155	0.01
HYBRID SUNFISH	12	0.01	193	0.01	116	0.01	1759	0.02
SAUGER	132	0.08	20607	1.54	1124	0.09	193209	1.92
RIVER DARTER	8	0.01	43	0.00	56	0.00	301	0.00
YELLOW PERCH	3	0.00	108	0.01	29	0.00	780	0.01
WALLEYE	34	0.02	294	0.02	238	0.02	2058	0.02
LOGPERCH	8	0.01	136	0.01	56	0.00	952	0.01
FRESHWATER DRUM	17903	11.21	183657	13.76	131129	11.06	1356903	13.50
TOTAL FISH	159647	100.00	1334570	100.00	1186041	100.00	10051790	100.00

TABLE 8 COMPARISON OF IMPINGEMENT ESTIMATES PREPARED DURING THE PRESENT STUDY WITH THOSE REPORTED DURING THE PREVIOUS STUDY AT THE CLIFTY CREEK STATION

	DEC 1985-NOV 1986		JAN 1986-DEC 1986		1977-78	
	No.	kg	No.	kg	No.	kg
Gizzard shad	727,545	5,851	1,026,867	7,854	1,938,955	19,191
Freshwater drum	181,405	1,786	131,129	1,357	76,724	1,258
Bluegill	11,792	119	12,364	126	7,314	45
White bass	6,661	170	6,357	141	14,077	618
Sauger	1,208	212	1,124	193	13,165	690
Channel catfish	1,099	39	1,026	37	1,479	72
Skipjack herring	812	29	819	29	177,204	993
Total Fish	937,453	8,563	1,186,041	10,518	2,253,696	23,448

3.6 IMPACT ASSESSMENT

The assessment of impingement impact on fish populations at the Clifty Creek Station can only be qualitative because estimates are not available regarding populations of the various species inhabiting this section of the Ohio River. Regardless of which 12-month period is chosen, the estimated annual impingement is <819 individuals for 46 of the 53 species collected during the study (Tables 6 and 7). Studies of the middle Ohio River show that for many species (e.g., most minnows, white crappie, carp, river carpsucker, and others) the annual estimated impingement loss at the Clifty Creek Station is comparable to the number of fish that can be collected during short-term fisheries surveys (ORSANCO 1981, ESE 1987). Therefore, it is clear that the impingement rates are too low to cause any impact to the populations of these 46 species. Those 7 species whose annual impingement loss is estimated to exceed 1000 fish and which need to be considered further are: channel catfish (1026-1099), sauger (1124-1208), emerald shiner (1346-1430), white bass (6357-6661), bluegill (11,792-12,364), freshwater drum (131,129-181,405) and gizzard shad (727,545-1,026,867).

The annual loss of 1300-1400 emerald shiner is inconsequential for the species considered by Pearson and Krumholz (1984) to be the most abundant fish in the river. ESE (1987) collected 1358 emerald shiners electrofishing and seining near RM 494. Pearson and Krumholz (1984) describe the channel catfish as being abundant throughout the river. They calculated the standing crop of channel catfish to be about 300 fish per hectare in this reach of the river. More than 100 channel catfish have been taken consistently from the lock chamber samples at Markland which is located less than 30 miles from the Clifty Creek Station (ORSANCO 1981). Thus, the annual loss of about 1000 small channel catfish is insignificant. Pearson and Krumholz (1984) consider the sauger to be common in the Ohio River. The current impingement level is one-tenth of the previous study period and impingement of 1100-1200 small to medium sauger over the course of one year is not cause for concern. For example, the lock chamber studies at Markland have yielded as many as 108 sauger in a single sample (ORSANCO 1981).

White bass is a common Ohio River species whose general abundance and high fecundity (average number of eggs per female = 565 thousand; Riggs 1955) make the annual loss of 6500 individuals insignificant. Moreover, the fact that most of the individuals impinged were YOYs and juveniles (see Section 3.3) further mitigates the loss of this number.

According to Pearson and Krumholz (1984), the bluegill is the most abundant centrarchid in the Ohio River and is particularly abundant in the middle third of the river where the Clifty Creek Station is located. Becker (1983) indicates that "dense populations of bluegill are possible because they are largely primary consumers." As discussed in Section 3.3, nearly 90% of the bluegills impinged were <100 mm. The annual loss of about 12,000 small bluegills is not biologically significant.

The estimated impingement loss for freshwater drum is about 130-180 thousand individuals (Table 8). Pearson and Krumholz (1984) reported that between RM

500 and 600 freshwater drum was the most abundant species in lock chamber samples during the most recent time period they analyzed (1978-1980). It is also a species that has very high fecundity; adult females may yield more than one half million eggs (Becker 1983). Furthermore, the bouyant nature of drum eggs ensures that the species is widely distributed. The impingement catch at the Clifty Creek Station was dominated (90 percent) by small (<140 mm) drum. Given the above facts, the annual impingement losses at the Clifty Creek Station pose no threat to this prolific species.

Pearson and Krumholz (1984) characterize the gizzard shad as one of the most abundant fishes in the river and estimate that its standing crop in this reach of the river has varied from 100-4300 individuals per hectare. It has typically been the second or third most abundant species in the adult fish catch at the Tanners Creek Plant located about 70 miles upriver of the Clifty Creek Station (Geo-Marine 1986). Fecundity of gizzard shad is high; production of one half million eggs per female is not uncommon (Bodola 1964). Although the current annual impingement estimate for the Clifty Creek Station is about one million shad, this is less than half the estimate derived during the 1977-78 study (Energy Impact Associates 1978). The high fecundity and abundance of this species suggest that impingement losses of one million (mostly YOY) gizzard shad are not biologically significant.

3.7 ANCILLARY DATA

The number of fish that were dead before being impinged was highest during November and December (Table 9). Gizzard shad accounted for most of those fish. Because it is often quite difficult to accurately differentiate between regularly impinged fish and those that were dead prior to being impinged, the numbers presented in Table 9 should be considered conservative estimates.

Median velocity ranged from 0.50 m/s (1.8 ft/s) to 0.9 m/s (3.0 ft/s), with most values between 0.6 and 0.7 m/s (2.0-2.3 ft/s) (Appendix A). No pattern regarding intake velocity and river stage was apparent (Appendix A).

Dissolved oxygen (DO) values ranged from 4.0 to 14.6 mg/l (Appendix A). Average daily values below 5 mg/l occurred on only two dates, 22 August (4.6 mg/l) and 28 August (4.9 mg/l).

TABLE 9   FISH COLLECTED AT THE CLIFTY CREEK STATION THAT WERE DEAD PRIOR TO BEING IMPINGED.

Species	Dec	Jan		Feb		Mar				Apr				
	11	9	22	6	16	6	11	21	24	2	10	15	25	28
Paddlefish	1													
Gizzard shad		2		26	2	169	3	6	551	54	31	12	70	10
Skipjack herring														
Mooneye						2								
Goldeye						1				1				
Carp							1							
Silver chub			1					1	1					
Emerald shiner											1			
Quillback											1			
Smallmouth buffalo													1	
Golden redhorse														
Redhorse sp.														
Carpsucker/Buffalo						1								
White bass			2			3			2	4	1			
Striped bass			1		1									
Channel catfish						1				1				
Bluegill			2			2				2			1	
Longear sunfish						1								
Rock bass														
Largemouth bass						1		1						
Spotted bass						1								
Logperch														
Sauger			1	4		1			3	6				
Freshwater drum				4		12		1	38	3	1		15	

TABLE 9 (CONT.)

Species	May 8	May 14	May 22	May 30	Jun 4	Jun 13	Jun 19	Jun 24	Jun 30	Jul 15	Jul 21	Aug 1	Aug 6	Aug 12	Aug 22	Aug 28
Paddlefish																
Gizzard shad	30	33	11	12	2	4	2			74	1	6	5	8	3	1
Skipjack herring																2
Mooneye																1
Goldeye		1														
Carp																
Silver chub																
Emerald shiner																
Quillback																
Smallmouth buffalo																
Golden redhorse		1														
Redhorse sp.		1														
Carpsucker/Buffalo																
White bass	1			3					1	2	1					
Striped bass																
Channel catfish							3	3		1	1	2				
Bluegill		2		1	1								1	1		
Longear sunfish																
Rock bass						1										
Largemouth bass																
Spotted bass																
Logperch	1															
Sauger		1	1													
Freshwater drum	3	5	1	2	1	1	2			47		3	2		19	1

TABLE 9 (CONT.)

Species	Sep					Oct				Nov				Dec		
	3	8	18	26	30	10	15	23	27	7	13	19	25	1	12	18
Paddlefish																
Gizzard shad	3	4	1	5	157	925	512	233	300	88	275	966	689	940	3451	183
Skipjack herring																
Mooneye																
Goldeye																
Carp																
Silver chub																
Emerald shiner																
Quillback																
Smallmouth buffalo																
Golden redhorse																
Redhorse sp.																
Carpsucker/Buffalo																
White bass					2							5			1	
Striped bass																
Channel catfish					3							4				
Bluegill	1				19										2	
Longear sunfish																
Rock bass																
Largemouth bass												2				
Spotted bass																
Logperch																
Sauger														1		
Freshwater drum	2			3	54	699	20	13	3	2	95	247	241	111	71	28

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